THE NIKANASSIN FORMATION OF THE TYPE AREA NEAR CADOMIN, ALBERTA

ADAM A. W. KRYCZKA

1959

THE UNIVERSITY OF ALBERTA

THE NIKANASSIN FORMATION OF THE TYPE AREA, NEAR CADOMIN, ALBERTA

A DISSERTATION

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

FACULTY OF ARTS AND SCIENCE

DEPARTMENT OF GEOLOGY

by

ADAM ALEXANDER WILLIAM KRYCZKA, B. Sc.

EDMONTON, ALBERTA

June, 1959

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Nikanassin Formation of the Type Area, Near Cadomin, Alberta", submitted by Adam Alexander William Kryczka, B.Sc. in partial fulfilment of the requirements for the degree of Master of Science.

PROFESSOR

PROFESSOR

PROFESSOR

June, 1959

ACKNOWLEDGEMENTS

The writer wishes to express his sincerest appreciation to all members of the Department of Geology for helpful suggestions in various phases of this work. Especial acknowledgements are due to Dr. J.F. Lerbekmo for his guidance and supervision of the sedimentary aspects of the thesis and to Dr. C.R. Stelck for his helpful criticism of the palaeontology and stratigraphy portions of the thesis.

The writer is indebted to Dr. A.D. Baillie and the management of the British American Oil Company in Calgary for their assistance in field matters.

The author's gratitude is also extended to the International Nickel Company of Canada, Ltd., who provided a Graduate Research Fellowship which enabled completion of the thesis.

The writer also wishes to thank Miss Karen Giebelhaus for her assistance in preparing illustrative material and for the typing of this thesis.

ABSTRACT

Four sections of type late Jurassic Nikanassin formation from the central foothills of Alberta are presented.

Mechanical analyses of seven samples are given on histograms and cumulative frequency curves. A depauperate foraminiferal assemblage is listed. Heavy mineral descriptions are given throughout a complete section and eighty-two thin sections are analyzed.

The Nikanassin formation belongs to the upper part of the Oxfordian stage and subsequent Jurassic stages. The Nikanassin is partially marine and partially continental; deposition may have taken place in shallow embayments connected to the open sea by narrow channelways. The Nikanassin was largely derived from pre-existing sediments.

TABLE OF CONTENTS

LIST OF PLATES, FIGURES AND TABLES

PLATES Page

FIGURES Page

TABLES

Frontispiece

View of a portion of the Nikanassin coal basin between Cadomin and Mountain Park, Alberta. Looking northwest from upper Mackenzie Creek towards distinctive Mt. Cheviot.

CHAPTER ONE

INTRODUCTION

General Statement

This study of the Nikanassin formation of the type area near Cadomin, was undertaken for two principal reasons. First, that the results might be used as partial guiding criteria for future correlation problems of the Nikanassin formation and second, that this work might initiate and promote similar studies of the other formations present in this popular area of field school geology.

Material Used

With the exception of the megafossils, all of the material was collected by the author during the spring, summer, and fall of 1958. The megafossils were collected by Drs. P.S. Warren and C.R. Stelck and loaned to the writer for presentation.

Study of the area began in May, 1958, resumed periodically in July and September, and was finally completed on October 16, 1958. During these periods, the author spent a total of 36 days in the field.

The samples collected in the field and later analyzed at the University of Alberta geological laboratories were obtained from the following sections:

(1) Cadomin Railroad (C.R.R.-1)

Longitude -- 117° 19' 55"

Latitude -- 53° 00' 45"

Total thickness measured -- 961 feet.

(2) Mountain Park Railroad (M.P.R.R.-1)

Longitude -- 117° 18' 10"

Latitude -- 52° 57' 00"

Total thickness measured -- 402 feet.

(3) Mackenzie Creek (M.K.C.-1)

Longitude -- 117° 10' 30"

Latitude -- 52° 56' 45"

Total thickness measured -- 1265 feet.

(4) Prospect Creek (P.P.C.-1)

Longitude -- 117° 20' 00"

Latitude -- 52° 57' 15"

Total thickness measured -- 59 feet.

The exact positions of these sections and fossil localities are shown on the location map included in this chapter. Detailed lists of the samples taken, along with similar lists of the samples used in the various studies, are presented in Appendix D.

Previous Work

To date, there have been no single specific works written on either the Nikanassin formation of the type area, or on the Nikanassin formation in general. MacKay first introduced the term Nikanassin into geological literature in 1929-30.

Thus, although the formation did not attain proper stratigraphic status until this late date, it nevertheless had been encountered by previous workers both in the type area and those regions closely related to it. The earliest of these investigations was a geological reconnaissance

carried out by J. McEvoy (1898). Eight years later, G.S. Malloch (1906) entered the region and established the main stratigraphic divisions of the Mesozoic rocks of the Bighorn basin, which is the southern structural counterpart of the Nikanassin coal basin. D.B. Dowling (1908) did much towards unravelling and deciphering the complicated geological structures in the area. Still later, J.S. Stewart (1916) described briefly the stratigraphy of the Mountain Park and adjacent coal areas, and J. MacVicar (1919 and 1923) compiled some of the general geology along the Athabasca River. Concluding the line of early workers are J.A. Allan and R.L. Rutherford (1923-27), who issued excellent maps and geological reports covering the Foothills Belt between the North Saskatchewan and Athabasca Rivers.

Since MacKay's work (1929-30), only minor attention has been given the Nikanassin formation, and this mainly from the standpoint of trying to determine its true relationship to the Jurassic-Cretaceous contact. Papers in which this aspect was treated were published by Berry (1929), Crombie (1946), Erdman (1945, 1946 and 1950), Lang (1947), Frebold (1953 and 1957), and others.

CHAPTER TWO

STRATIGRAPHY

STRATIGRAPHIC STATUS

The regional type area of the Nikanassin formation is the Nikanassin or Mountain Park coal basin, which extends from the North Saskatchewan River 65 miles northward to beyond the McLeod River, and has an average width of eight miles. The first Nikanassin outcrop, however, was named, measured, and described by B.R. MacKay (1930) near Cadomin, Alberta; consequently, this locality is designated as the type area of the formation. The Nikanassin formation of the type area near Cadomin, is mainly a succession of interbedded medium- to dark-grey, brownish-weathering, very fine and fine-grained carbonaceous sandstones and dark-grey silty shales. The formation which is partly marine and partly continental, is overlain by the Cadomin conglomerate and underlain by the beds of the Fernie group. MacKay did not set up any single exposure as a type section of the Nikanassin formation, and as a result, definition of the lower limit of the formation has been largely left open to personal judgement.

In the eastern Foothills belt, for example, Beach (1942), Henderson (1944-45), and Erdman (1946-50) have recognized the possibility that some of the sandstone beds included in the upper part of the Fernie group may represent an occurrence of the Nikanassin formation. Similarly, in the westermost parts of the north central Foothills, Malloch (1911), Lang (1947), and Irish (1951) have arbitrarily selected certain massive sandstones to mark the Nikanassin-Fernie contact. In order to alleviate

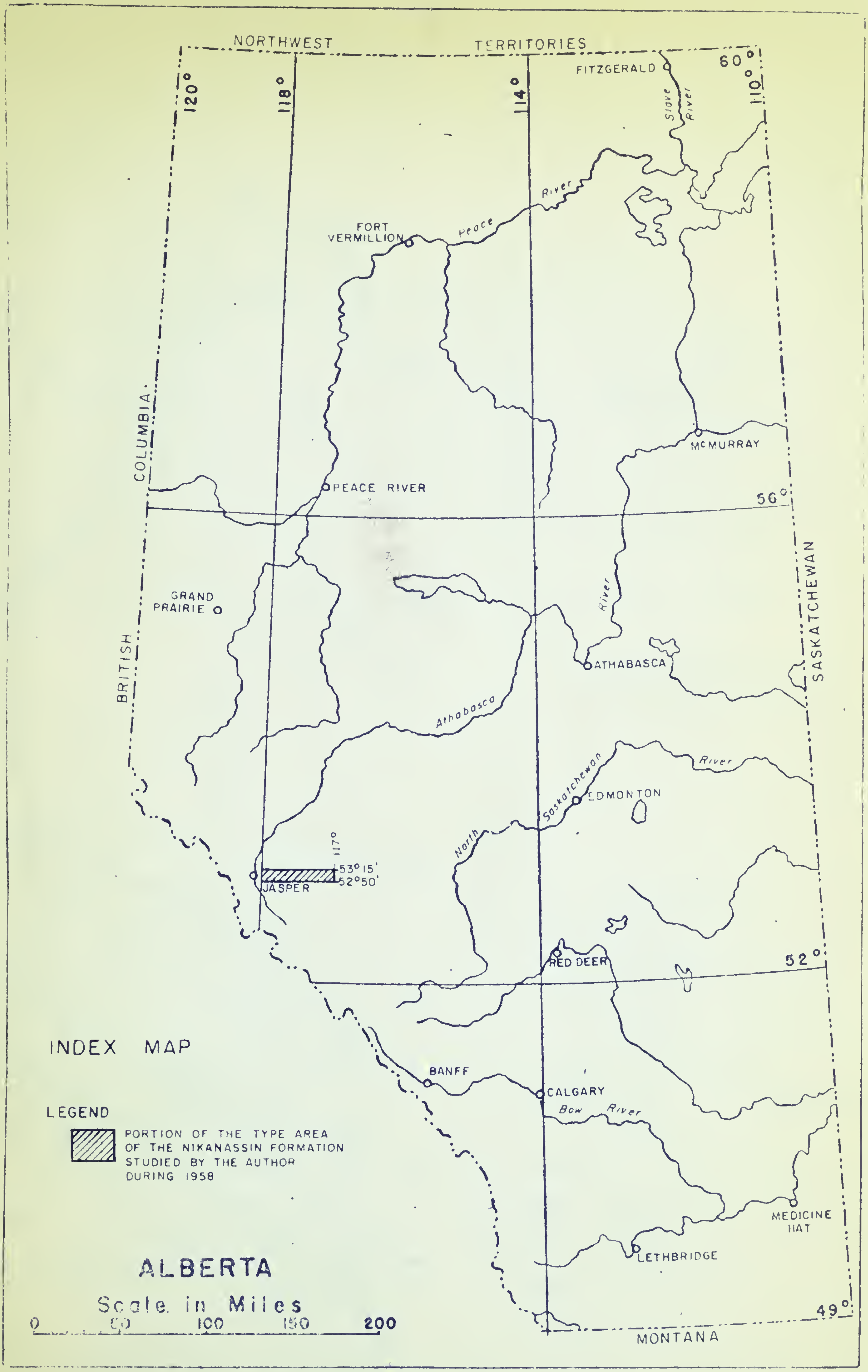

NORTHWEST TERRITORIES
120°
118°
114°
110°
60°
FITZGERALD
Slave River
Peace River
FORT VERMILLION
McMURRAY
COLUMBIA
BRITISH
PEACE RIVER
56°
SASKATCHEWAN
GRAND PRAIRIE
River
ATHABASCA
Athabasca
River
North Saskatchewan
EDMONTON
117°
53°15'
52°50'
JASPER
RED DEER
52°
INDEX MAP
LEGEND
PORTION OF THE TYPE AREA OF THE NIKANASSIN FORMATION STUDIED BY THE AUTHOR DURING 1958
BANFF
CALGARY
Bow River
MEDICINE HAT
LETHBRIDGE
ALBERTA
Scale in Miles
0 50 100 150 200
49°
MONTANA

FIGURE 1

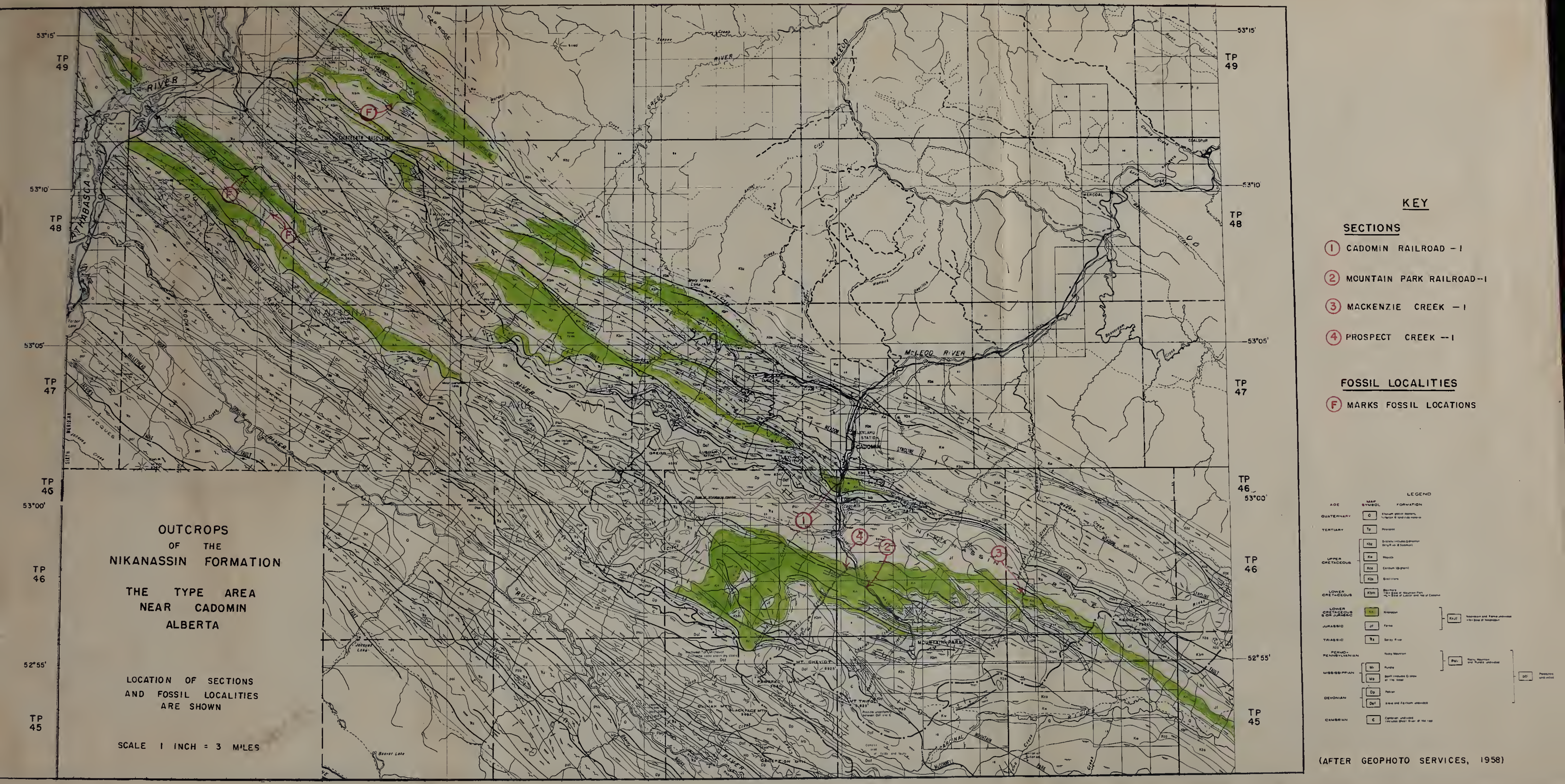

OUTCROPS
OF THE
NIKANASSIN FORMATION
THE TYPE AREA
NEAR CADOMIN
ALBERTA
LOCATION OF SECTIONS
AND FOSSIL LOCALITIES
ARE SHOWN
SCALE 1 INCH = 3 MILES
KEY
SECTIONS
1 CADOMIN RAILROAD - I
2 MOUNTAIN PARK RAILROAD - I
3 MACKENZIE CREEK - I
4 PROSPECT CREEK - I
FOSSIL LOCALITIES
F MARKS FOSSIL LOCATIONS
(AFTER GEOPHOTO SERVICES, 1958)
CADOMIN
McLEOD RIVER
MOUNTAIN PARK
MT. CHEVIOT
COALSPUR
MERCOAL
ATHABASCA
53°15'
53°10'
53°05'
53°00'
52°55'
TP 49
TP 48
TP 47
TP 46
TP 45

FIGURE 2

this problem, the author has presented a suggested delineation of the type contact between the beds of the Nikanassin formation and the Passage bed equivalents of the Fernie group as examined at Prospect Creek in the type area (see Plate 9, p. 57).

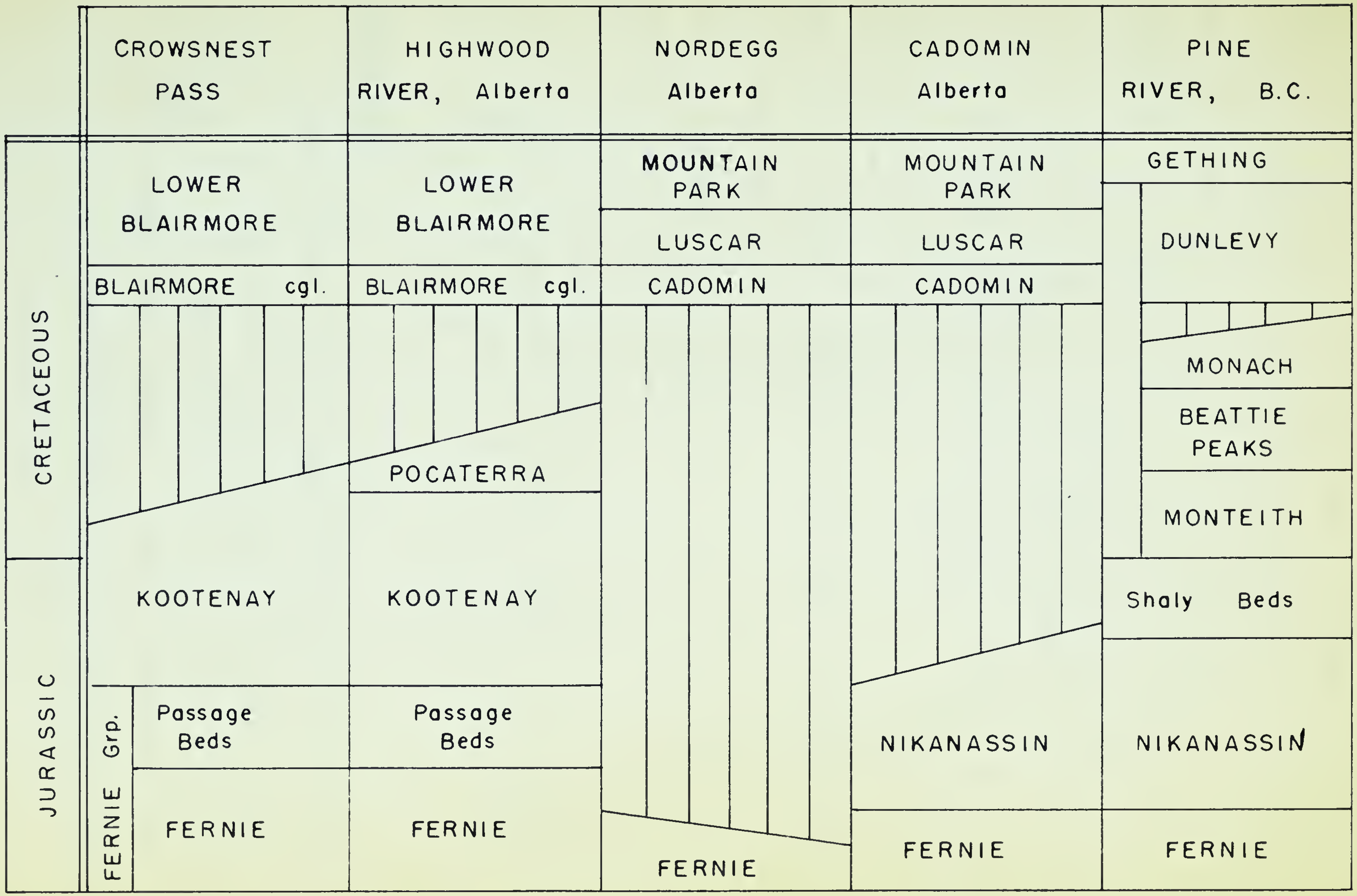
AGE AND CORRELATION

Although considerable controversy has arisen over the age of the Nikanassin, the author feels that the palaeontological evidence presented, coupled with the work of Warren and Stelck (1958), indicates that the Nikanassin of the type area is Upper Jurassic, partially Oxfordian, and later in age.

The correlation of the Nikanassin formation has long been a contentious problem. Earliest workers equated the Nikanassin formation of the north central Foothills with the Kootenay formation of the southern belt. This correlation was based largely on the following flora which are recognized in both formations; *Gingko* cf. *lepida* Heer, *Gingko nana* Dawson, *Czekanowskia* cf. *rigida* Heer, and *Podozamites lanceolatus* (Lindley and Hutton).

In a recent paper, Warren and Stelck (1958) have presented a correlation of the Upper Jurassic and Lower Cretaceous formations of the Canadian Rockies, and in so doing have shown the stratigraphic position of the Nikanassin formation of the type area and its relationships. The age, as indicated by the Lower Kootenay flora at the top and the *Aucella* at the base, barring unnoted diastems, probably reaches from Oxfordian through to Portlandian and perhaps part of Tithonian. The Nikanassin lacks the Upper Kootenay flora; therefore, one questions

TABLE 1



CORRELATION CHART OF JURASSIC — EARLY CRETACEOUS FORMATIONS OF THE CANADIAN ROCKY MOUNTAINS
(After Warren and Stelck 1958)

whether it reaches as high as the basal Cretaceous zones.

After having spent four months examining sections of the Kootenay formation from the Crowsnest Pass north to the Bow River, and another six weeks studying the outcrops of the Nikanassin formation of type area, the author agrees with Warren and Stelck as to the age of the Nikanassin in the Cadomin area, and supports their correlation. A correlation chart expressing diagrammatically the outcrop relationships of the Nikanassin formation is included in this chapter (see Table 1, p. 8).

In the region of the Pine Pass, British Columbia, the Nikanassin formation of the Cadomin area is correlative with 3500' of Nikanassin sandstones and the lower portion of a 500' shaly interval overlying these sands. However, probably the most important stratigraphic aspect illustrated in the chart is that only the lowermost Kootenay strata of both the Highwood and Crowsnest Pass areas are correlative with the uppermost part of the Nikanassin formation of the type area. The basal portion of the Nikanassin formation of the north central Foothills is equated to the Passage beds of the Fernie group in the southern Foothills area and a small portion of the top of the Fernie shale itself.

CADOMIN AREA

Although only one section, Cadomin Railroad-1 (C.R.R.-1), was studied in the immediate vicinity of Cadomin, the author spent three days carrying out preliminary checks of the sections west of Cadomin along the Palaeozoic thrust sheet. MacKay has indicated these sections as probably complete but overturned. None of the sections proved useful, as in all cases the rocks were mostly covered.

Section C.R.R.-1, whose location is shown in Figure 2 (see p. 6), is believed to be the first outcrop of Nikanassin examined by MacKay in this area in 1928. The exposure today (mapped by MacKay in 1929) no longer shows a complete Nikanassin sequence, since recently talus from a nearby limestone quarry has concealed a portion of the Lower Nikanassin. Also covered are the beds of the Fernie group and the Nikanassin-Fernie contact.

The exposed Nikanassin interval was measured to be 970 feet thick and is capped by 39 feet of Cadomin conglomerate.

MOUNTAIN PARK AREA

Three sections of the Nikanassin formation were measured, sampled, and described near the abandoned coal mining town of Mountain Park. The positions of these sections, Mackenzie Creek-1, Mountain Park Railroad-1, and Prospect Creek-1 are plotted on the outcrop map (see Fig. 2, p. 6).

None of these three exposures constitutes a complete undisturbed section of the Nikanassin formation. Of the three sections, Mackenzie Creek-1 (M.K.C.-1) is the most complete and reaches a thickness of 1265 feet below the Cadomin conglomerate before being terminated by a fault. Although this lower portion of the section is repeated by the fault, the lithologic equivalent of the section ending at 1265' was recognized and was visually estimated as being 200' above the base. Thus, it would appear that the total thickness of the Nikanassin formation of the type area is about 1465 feet.

The other sections, Mountain Park Railroad-1 (M.P.R.R.-1) and Prospect Creek-1 (P.P.C.-1) are much thinner than the Mackenzie Creek exposure since they represent only portions of the complete formation. Section M.P.R.R.-1 is 402 feet thick and includes the uppermost Lower and some Middle Nikanassin strata. Section P.P.C.-1 is only a thickness of 53 feet and shows rather well a logical break between the Passage bed equivalents of the Fernie group and the Nikanassin formation.

The stratigraphic relationships of the four sections of the Nikanassin formation of the type area are illustrated in Figure 2A.

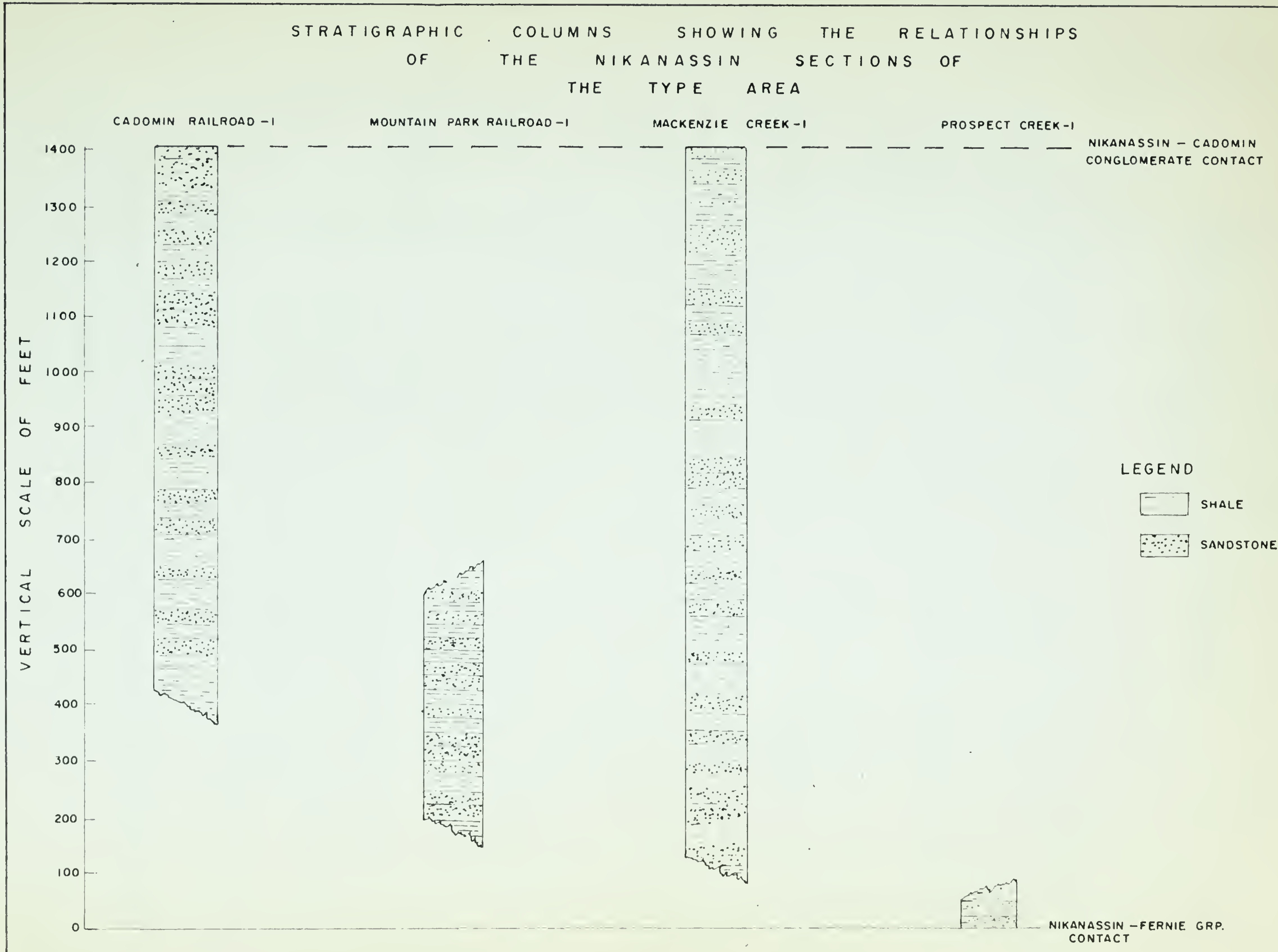

STRATIGRAPHIC COLUMNS SHOWING THE RELATIONSHIPS OF THE NIKANASSIN SECTIONS OF THE TYPE AREA
CADOMIN RAILROAD -1
MOUNTAIN PARK RAILROAD -1
MACKENZIE CREEK -1
PROSPECT CREEK -1
NIKANASSIN – CADOMIN CONGLOMERATE CONTACT
NIKANASSIN –FERNIE GRP. CONTACT
VERTICAL SCALE OF FEET
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
LEGEND
SHALE
SANDSTONE

FIGURE 2A

CHAPTER THREE

DETAILED LITHOLOGY OF SECTIONS MEASURED IN THE TYPE AREA

Since approximately six weeks were spent describing, measuring, and sampling sections in the Cadomin area, and since no lithologic descriptions of the Nikanassin formation of the type area are available in the literature, the author has devoted this chapter to the presentation and illustration of this basic information.

Each section was measured using a 5-foot Jacob's staff, a 100-foot tape, and a Brunton compass. Although both the thicknesses of the outcrop and covered intervals were measured with the 5-foot Jacob's staff, the thicknesses of the covered intervals were also checked trigonometrically using measurements made with the 100-foot tape. All of the sections except Prospect Creek-1 were measured stratigraphically downwards.

The detailed lithologic section descriptions included in this chapter were condensed from the author's field notes. Following are the references to some of the standards which were adhered to in compiling the descriptions;

(a) Color terminology -- G.S.A. Rock Color Chart (1951)

(b) Definition of grain size parameters -- Wentworth's Size Classification (Twenhofel and Tyler, 1941)

(c) Bedding and splitting terminology -- modified from McKee and Weir (1953)

The bedding and splitting terminology, modified from McKee and Weir (1953), is shown in Table 2 (see p.14).

THICKNESS OF STRATA NOMENCLATURE

TABLE 2

STRATIFICATION TERMINOLOGY		CROSS-STRATIFICATION TERMINOLOGY		THICKNESS	SPLITTING TERMINOLOGY
VERY THICK BEDDED	BEDS	VERY THICKLY CROSS-BEDDED	CROSS-BEDS	> 120 cms. >(4 ft.)	MASSIVE
THICK BEDDED		THICKLY CROSS-BEDDED		120 - 60 cms. (2 - 4 ft.)	BLOCKY
MEDIUM BEDDED		MEDIUM CROSS-BEDDED		60 - 5 cms. (2 ft. - 2 in.)	SLABBY
THIN BEDDED		THINLY CROSS-BEDDED		5 - 1 cm. (2 - 1/2 in.)	FLAGGY
LAMINATED	LAMINAE	CROSS-LAMINATED	CROSS-LAMINAE	1 cm. - 2 mm. (1/2 - 0.08 in.)	SHALY (if SILTSTONE or CLAYSTONE) PLATY (if SANDSTONE or LIMESTONE)
THINLY LAMINATED		THINLY CROSS-LAMINATED		<2 mm. <(0.08 in.)	PAPERY

(MODIFIED AFTER McKEE and WEIR, 1953.)

DESCRIPTION OF OUTCROP SECTIONS

SECTION: Cadomin Railroad-1-58
CODE: C.R.R.-1-58
FORMATION: Nikanassin Formation
LOCATION: Longitude: 117° 19' 55"
Latitude: 53° 00' 45"

Nikanassin-Cadomin Contact

The actual Cadomin-Nikanassin contact is well exposed. The base of the Cadomin Conglomerate rests on a 1 1/2" grey shaly "soil-like" material or mud. The conglomerate base is made of cobbles which are somewhat pressed into this soft mucky "soil-like" material. Where the "soil" has been removed, only a rough undulating cobble and pebble conglomerate surface remains. This surface weathers light orangish brown and is stained dark black in other places. Also noticeable on this surface are depressions 2" - 3" deep and of all shapes.

There appears to be no structural deformation at the actual contact.

Nikanassin Formation

Interval	Description
0 - 1'	SHALE, dark-brownish-grey, weathers light orange brown, semifissile to crumbly, recessive, noncalcareous, sandy to silty, micromicaceous, carbonaceous streaks present.
1 - 1'4"	CLAY IRONSTONE BAND, nodules are almost square but have rounded corners, nodules have no core material - medium- to dark-grey, weathers orange brown, resistant and hard, fractured into "squares" perpendicular to the dip, noncalcareous, micromicaceous, ferruginous, no fossils.
1'4" - 1'8"	SHALE, dark-grey, weathers medium orangish brown, fissile, very slightly calcareous, no mica, not sandy or silty.
1'8" - 2'4"	COAL, Note: The coal is probably crossed by a minor fault as the thickness is variable and tends to pinch out down dip - black, lustrous, flaky, recessive.
2'4" - 5'10"	SHALE, blackish and greyish-brown, weathers light brown and light orangish brown, fissile to platy, calcareous, sandy, micromicaceous, traces of black carbonaceous material along bedding planes.

Interval	Description
5'10" - 7'4"	Interbedded sandstone and shale 65% shale - 35% sandstone
	SHALE, dark-brownish-grey, weathers dark blackish grey, fissile, recessive, laminated, slightly calcareous, carbonaceous (?).
	SANDSTONE, dark-brownish-grey, weathers dark grey, fine-grained, thin-bedded, flaggy, no laminae, calcareous, argillaceous, carbonaceous, micromicaceous, porosity (intergranular) fair.
7'4" - 8'	Clay ironstone and shale.
	CLAY IRONSTONE NODULES present are identical with those in interval 1' - 1'4" except they are smaller and are surrounded by a fissile, orange-brown shale.
	SHALE, dark-grey, weathers moderate orange brown, fissile, noncalcareous, no mica, some black carbonaceous and coal partings.
8' - 9'6"	SANDSTONE, medium-blackish-brown, weathers medium grey and light brown, fine- to very fine grained, micaceous, laminated, thin-bedded, calcareous, micaceous, argillaceous, porosity (intergranular) fair to poor.
9'6" - 10'6"	SHALE, dark-blackish-grey, weathers black, fissile, recessive, noncalcareous, coaly, no silt, micromicaceous.
10'6" - 14'	Interbedded sandstone and shale 55% shale - 45% sandstone
	SHALE, dark-grey, weathers light brownish grey and light whitish brown, fissile, no laminae, slightly calcareous, slightly micaceous, carbonaceous.
	SANDSTONE, medium- to dark-brownish-grey, weathers light to medium brown, fine-grained, laminated, argillaceous, calcareous, carbonaceous, some micromica, porosity (intergranular) fair to poor.
14 - 37'	Sandstone with minor platy silty sandstone intercalations.
	SANDSTONE, dark-grey and dark-brownish-grey, weathers light orange brown, fine- to very fine grained, thick- to medium-bedded, highly laminated, slightly calcareous, carbonaceous, argillaceous, some mica, porosity (intergranular) fair.

Interval	Description
	SANDSTONE INTERCALATIONS, dark-blackish-grey, weathers light orange brown, very fine grained, fissile to platy, carbonaceous - otherwise is same as sandstone above.
37 - 48'	Interbedded sandstone and shale 50% shale - 50% sandstone
	SANDSTONE, dark-grey, weathers light to medium greyish brown and light orangish brown, very fine to fine-grained, laminated and cross-bedded, carbonaceous, calcareous, some mica, argillaceous, porosity (intergranular) fair to good.
	SHALE, dark-blackish-grey, weathers dark greyish brown and medium to dark grey, crumbly to fissile, recessive, slightly calcareous, slightly silty, micromicaceous, carbonaceous.
48 - 53'6"	SANDSTONE, medium- to dark-grey, weathers medium greyish brown and light orangish brown, very fine grained, extremely finely and regularly laminated, calcareous, carbonaceous, argillaceous, slight traces of micromica, porosity (intergranular) fair to good.
53'6" - 55'	SHALE, dark-brown, weathers medium greyish brown, crumbly, recessive, slightly calcareous, silty, micromicaceous, noncarbonaceous.
55 - 67'	SANDSTONE, dark-grey, weathers light whitish grey and light greyish brown, fine- to medium-grained, thick- to medium-bedded, lustrous black coal and carbonaceous partings common, slightly calcareous, micaceous, argillaceous, carbonaceous, contains small clay nodules, porosity (intergranular) fair.
67 - 71'6"	SANDSTONE, dark-grey and medium-brownish-grey, weathers medium grey and light greyish brown, very fine to fine-grained, laminated, thin-bedded, micaceous, carbonaceous, argillaceous, calcareous, porosity (intergranular) poor.
71'6" - 77'	Interbedded sandstone and shale 55% sandstone - 45% shale
	SANDSTONE, dark-grey, weathers medium brown and light orange brown, very fine grained, thin-bedded, carbonaceous, laminae, micromicaceous, slightly calcareous, porosity (intergranular) poor.
	SHALE, dark-grey and black, weathers black, fissile to crumbly, recessive, carbonaceous, very slightly calcareous, not sandy or silty;

Interval	Description
77 - 80'6"	COAL, black, fissile to flaky, recessive, shaly near the top.
80'6" - 86'6"	SANDSTONE, light-orangish-brown and dark-grey, weathers medium orange brown and medium to dark grey, very fine grained, thin-bedded, platy, carbonaceous markings parallel to bedding, micaceous, argillaceous, carbonaceous, slightly calcareous, porosity (intergranular) poor to nil.
86'6" - 89'6"	SHALE, dark-grey, weathers medium to dark grey, fissile, recessive, slightly calcareous, very slightly silty, carbonaceous, micromicaceous.
89'6" - 92'	SANDSTONE, medium-brownish-grey with dark-black carbonaceous laminae, weathers dark grey and light yellowish orange, very fine to fine-grained, thin-bedded, carbonaceous, very slightly calcareous, coaly, argillaceous, micaceous, porosity (intergranular) poor - along fractures good.
92 - 93'	COAL, black, flaky to fissile, recessive.
93 - 95'	Interbedded sandstone and shale 65% sandstone - 35% shale SANDSTONE, medium- to dark-grey, weathers medium grey and light greyish brown, very fine grained, thin-bedded, streaked with dark grey and black carbonaceous material and coal, noncarbonaceous, micaceous, argillaceous, porosity (intergranular) poor. SHALE, dark-grey to black, weathers dark grey, fissile, recessive, noncalcareous, not sandy or silty, carbonaceous, micromicaceous.
95 - 102'	SANDSTONE, medium- to dark-grey with a slight brownish suggestion, weathers light orangish brown, very fine grained, strongly laminated, micaceous, calcareous, medium-bedded, porosity (intergranular) poor to fair.
102 - 107'	SHALE, dark-blackish-grey, weathers medium to light grey, fissile, recessive, noncalcareous, silty, micaceous, carbonaceous (?).
107 - 120'	Interbedded sandstone and shale 80% - 85% sandstone - 15% - 20% shale SANDSTONE, dark-grey, weathers light brown and light orangish brown, very fine grained, finely laminated and cross-bedded, thin- to medium-bedded, calcareous, argillaceous and/or carbonaceous, micaceous, porosity (intergranular) fair.

Interval	Description
	SHALE, dark-blackish-grey, weathers dark greyish brown, fissile, recessive, calcareous, micaceous, carbonaceous, not sandy or silty.
120 - 155'	Interbedded sandstone and shale 70% shale - 30% sandstone
	SHALE, medium-grey-brown, weathers medium and dark grey, fissile to crumbly, slightly calcareous, silty and sandy, contains carbonaceous and coaly material.
	SANDSTONE, dark-grey, weathers light brownish grey and light orangish brown, very fine grained, laminated, cross-bedded, thin-bedded, calcareous, carbonaceous, argillaceous, slightly micaceous, porosity (intergranular) poor to fair.
155 - 163'	Interbedded sandstone and shale 60% sandstone - 40% shale
	SANDSTONE, dark-grey, weathers light greyish brown and light orangish brown, fine- to medium-grained, laminated and finely cross-bedded, thin-bedded, calcareous, argillaceous, carbonaceous (?), micaceous, porosity (intergranular) fair to poor.
	SHALE, medium- to dark-grey, weathers light grey and light brownish grey, fissile, slightly calcareous, highly sandy, micromicaceous.
163 - 172'	SHALE, dark-grey, weathers medium to light grey and light orange brown, fissile, recessive, calcareous, sandy, micromicaceous, carbonaceous and coaly.
172 - 185'	Covered interval.
185 - 199'	Interbedded sandstone and shale 60% sandstone - 40% shale
	SANDSTONE, medium-greyish-brown, weathers light brown and light orangish brown, very fine grained, thin-bedded, slabby, highly laminated and cross-bedded, micaceous, argillaceous, carbonaceous, calcareous, porosity (intergranular) poor.
	SHALE, dark-blackish-grey, weathers light brown and medium grey where protected, fissile, calcareous, highly silty to sandy, carbonaceous along fissility planes.

Interval	Description
199 - 217'	Interbedded sandstone and shale 60% - 65% shale - 35% - 40% sandstone SHALE, dark-greyish-brown, weathers light orangish brown and medium to dark grey, fissile, recessive, calcareous, micromicaceous, very slightly silty. SANDSTONE, light-greyish-brown, weathers light orange brown, very fine grained, laminated and finely cross-bedded, extremely thin-bedded, calcareous, argillaceous, micaceous, porosity (intergranular) fair.
217 - 239'	Covered interval.
239 - 248'	Interbedded sandstone and shale 55% sandstone - 45% shale SANDSTONE, laminated dark-grey and light-orangish-brown, weathers light orange and orangish brown, very fine grained, thin-bedded, finely laminated and cross-bedded, slightly calcareous, micaceous, argillaceous, porosity (intergranular) fair to good. SHALE, dark-grey, weathers medium to dark grey, extremely fissile, recessive, slightly calcareous, micromicaceous, slightly silty.
248 - 273'	Covered interval.
273 - 275'	Poorly exposed shale outcrop. SHALE, laminated dark-grey and light- to medium-brown, weathers dark greyish brown and medium orange brown, fissile, noncalcareous, silty, micaceous.
275 - 303'	Covered interval.
303 - 320'	Shale with minor interbeds of flaggy to platy sandstone 75% - 80% shale SHALE, dark-greyish-brown with some lighter-brown laminae, weathers medium brown and light orange brown in places, very slightly calcareous, silty, micaceous. SANDSTONE INTERBEDS, light-brownish-grey and medium- to dark-grey laminae, weathers light brown and light to orange brown, very fine grained, thin-bedded, platy to flaggy, carbonaceous, calcareous, micaceous.

Interval	Description
320 - 327'	SHALE, dark-blackish-brown, weathers dark grey and light brownish grey, fissile to crumbly, semi-recessive, noncalcareous, carbonaceous, very slightly silty, shale contains flat discoidal nodules lying parallel to the bedding, shale is extremely micaceous.
327 - 330'	SHALE, dark-grey and light-grey-brown, weathers light brownish grey, fissile and recessive, laminated, calcareous, micaceous, sandy and partially carbonaceous.
330 - 334'	SANDSTONE, medium- to dark-grey with medium-light-grey laminae, weathers light and light reddish orange, fine- to very fine grained, thin-bedded, platy, laminated, cross-bedded, calcareous, argillaceous, carbonaceous, micaceous, porosity (intergranular) is fair.
334 - 342'	Covered interval.
342 - 346'	Interbedded sandstone and shale 60% sandstone - 40% shale SANDSTONE, laminated dark-blackish-grey and light-brownish-grey, weathers light brown and light orangish brown, very fine grained, thin-bedded, extremely finely laminated, calcareous, argillaceous, micaceous, porosity (intergranular) fair to poor. SHALE, dark-blackish-brown, weathers dark brown, fissile to crumbly, calcareous, not sandy or silty, micaceous (?), carbonaceous.
346 - 362'	Sandstone with very minor shale intercalations in upper 5'. SANDSTONE, laminated medium-grey and dark-blackish-grey, weathers light brown and light orangish brown, fine- to very fine grained, thin-bedded, finely laminated and cross-bedded, flaggy to platy, slightly calcareous, argillaceous and carbonaceous, micaceous, porosity (intergranular) fair. SHALE INTERCALATIONS, Medium- to dark-brown, weathers light whitish grey and light greyish brown, fissile, very fine carbonaceous laminae present, slightly calcareous, very slightly silty to sandy, carbonaceous, micaceous (?).
362 - 369'	Covered interval.

Interval	Description
369 - 400'	Shale with two minor sandstone bands One sandstone band is 1' from base of interval; the other 3' from base SHALE, dark-blackish-grey, weathers dark greyish brown and light orange brown, fissile, semi-recessive, noncalcareous, silty, micromicaceous, carbonaceous (?). SANDSTONE BANDS, medium-grey, weathers bright light orange, fine-grained, thin-bedded, calcareous, partially quartzitic, micaceous, argillaceous (?), porosity (intergranular) poor.
400 - 405'	SANDSTONE, medium- to light-grey, weathers light brown and bright orange, very fine grained to fine-grained, thin-bedded, slabby to flaggy, carbonaceous staining and partings on bedding plane surfaces, very slightly calcareous, argillaceous, carbonaceous, porosity (intergranular) poor.
405 - 468'	Covered interval.
468 - 472'	SHALE, black, weathers black, fissile, semi-recessive, no laminae, noncalcareous, slightly silty, carbonaceous to coaly.
472 - 487'	Sandstone with minor shale interbands in upper portion of the interval. SHALE, as in interval 468 - 472'. SANDSTONE, salt and pepper variety, medium-grey, weathers light reddish orange and light orangish brown, fine-grained, thin-bedded, slabby to flaggy, fractured perpendicular to the bedding and fractures filled with secondary yellowish white calcite, micaceous, argillaceous, calcareous, porosity (intergranular) fair.
487 - 707'	Covered interval.
707 - 717'	SANDSTONE, medium-brown and greyish-brown, weathers light brown and dark brownish grey, very fine grained, thin-bordering on medium-bedded, blocky, quartzitic, slightly calcareous, argillaceous, very little micromica, porosity poor.
717 - 724'	Covered interval.
724 - 727'	SANDSTONE, medium- to dark-grey, weathers dark grey and stains yellow and yellowish orange, very fine grained, less quartzitic than sandstone of previous interval, contains black lustrous coaly and carbonaceous partings along bedding planes, noncalcareous, argillaceous, porosity (intergranular) poor.

Interval	Description
727 - 733'	SANDSTONE, light-whitish-grey, weathers light whitish brown and light brownish grey, very fine to fine-grained, thin- to medium-bedded, noncalcareous, nonargillaceous, some "wispy" carbonaceous material present, porosity (intergranular) fair to poor.
733 - 743'	SANDSTONE, medium-brown, weathers light whitish brown and light grey, very fine grained, thin-bedded, slabby, traces of discontinuous carbonaceous laminae, very slightly calcareous, slightly carbonaceous, porosity (intergranular) poor.
743 - 765'	Covered interval.
765 - 768'	SHALE, dark-grey to black, weathering dark-greyish-brown and blackish-grey, fissile, recessive, calcareous, slightly silty, coaly and carbonaceous along partings, micaceous.
768 - 775'	SANDSTONE, light-grey and brownish-grey, weathers light brown and whitish grey, very fine grained, thin- to medium-bedded, slabby to blocky, lamellar markings, partially quartzitic, argillaceous, slightly carbonaceous, noncalcareous, porosity (intergranular) poor to nil.
775 - 788'	Covered interval.
788 - 797'	SANDSTONE, medium- to dark-grey, weathers light whitish grey and light yellowish brown, very fine to fine-grained, thin- to medium-bedded, flaggy to slabby, faint suggestion of lamination, quartzitic in part, slightly calcareous, argillaceous, slightly carbonaceous, micaceous, porosity (intergranular) fair.
797 - 800'	Covered interval.
800 - 804'	SANDSTONE, as in interval 788 - 797' except that the weathering color tends to be light yellowish brown with light grey being minor - also, has a blocky rather than slabby fracture.
804 - 831'	Covered interval.
831 - 833'	Interbedded sandstone and shale 75% - 80% sandstone - 25% - 20% shale SANDSTONE, dark-brownish-grey,-weathers light brown and light greyish brown, very fine grained, thin-bedded, no laminae, partially quartzitic, argillaceous, micaceous, slightly calcareous to noncalcareous, porosity (intergranular) poor.

Interval	Description
	SHALE, dark-brown, weathers medium to light greyish brown, fissile, recessive, noncalcareous, sandy, micaceous, bears some dark blackish grey carbonaceous or argillaceous filming or staining on fissility planes.
833 - 838'	SANDSTONE, light-greyish-brown, weathers light brown, very fine to fine-grained, thin-bedded, blocky, calcareous, some mica, very slight argillaceous content, porosity (intergranular) is fair to good.
838 - 863'	Covered interval.
863 - 868'	SANDSTONE, light-brownish-grey, weathers light brown with a medium grey stain in places, very fine grained, thin-bedded, thin carbonaceous partings, calcareous, silty, carbonaceous and argillaceous, micromicaceous, porosity (intergranular) is fair.
868 - 870'	SANDSTONE, dark-grey, weathers dark brownish grey, very fine grained, thin-bedded, no definite laminae, flaggy, slightly quartzitic, very slightly calcareous, highly argillaceous, partially carbonaceous (?), micaceous, porosity (intergranular) fair to good.
870 - 930'	Covered interval.
930 - 937'	SANDSTONE, medium-greyish-brown, weathers light yellowish and light orangish brown, very fine grained, thin-bedded, flaggy to slabby, slightly calcareous, argillaceous, partially carbonaceous (?), micromicaceous, porosity (intergranular) is fair.
937 - 943'	Covered interval.
943 - 961'	SANDSTONE, as in the interval 930 - 937'.

Plate I

A. Cadomin Railroad - Exposure of the uppermost 100 - 150' of Nikanassin beds along the Canadian National Railroad track near Cadomin - note the base of the Cadomin conglomerate is marked by a dark bed at the extreme left.

B. Cadomin Railroad - Close-up of the contact between the Cadomin conglomerate and the Nikanassin formation as seen in A. - note the difference in resistance of the two formations.

Plate II

A. Cadomin Railroad - Nikanassin beds comprising the unit which reaches from 100 - 200' below the Cadomin conglomerate - note the blocky resistant outcrops of sandstone and the fissile recessive nature of the shales.

B. General view showing highway-cut exposure of interbedded sandstones and shales of the "Lower" Nikanassin (left) near Prospect Creek and the darker greyish-brown shales of the Fernie formation (directly down the railway). These Fernie shales rest on the Rock Creek member which forms the small grass-covered hill to the right of the railroad track.

DESCRIPTION OF OUTCROP SECTIONS

SECTION: Mountain Park Railroad-1-58
CODE: M.P.R.R.-1-58
FORMATION: Nikanassin Formation
LOCATION: Longitude: 117° 18' 10"
Latitude: 52° 57' 00"

Section M.P.R.R.-1-58 was measured from the glauconite (?) beds of the Lower Nikanassin formation, stratigraphically down through to the Nikanassin-Passage Bed contact.

Nikanassin Formation

Interval	Description
0 - 3'6"	Sandstone with minor shale interbeds. SANDSTONE, medium-dark-grey, weathers pale yellowish brown and light orangish brown, very fine grained, thin-bedded, platy, slightly calcareous, carbonaceous, micaceous, argillaceous, glauconitic (?), porosity (intergranular) poor. SHALE, greyish-black, weathers medium dark grey, fissile, micaceous, carbonaceous, noncalcareous, slightly sandy.
3'6" - 26'	Shale with minor sandstone intercalations 90% - 95% shale - 10% - 5% sandstone SHALE, brownish-grey, weathers medium grey, fissile, recessive, slightly silty, noncalcareous, carbonaceous. SANDSTONE, as in interval 0 - 3'6" except it is thin-bedded and laminated.
26 - 30'	Covered interval.
30 - 35'	SANDSTONE, medium-light and medium-dark-grey, weathers pale yellowish brown, very fine grained, thin-bedded, slabby and blocky, laminated, very slightly calcareous, carbonaceous, argillaceous, micaceous, porosity (intergranular) poor.
35 - 41'	SHALE, dark-grey, weathers medium dark grey, fissile, semi-recessive, extremely micaceous, noncalcareous, carbonaceous, not silty or sandy.
41 - 46'	Interbedded sandstone and shale 40% sandstone - 60% shale

Interval	Description
	SANDSTONE, medium- to olive-grey, weathers pale yellowish brown to light olive grey, very fine grained, thin- to medium-bedded, blocky, slightly calcareous, argillaceous, carbonaceous, micaceous, porosity (intergranular) fair to poor.
	SHALE, dark-greyish-black, weathers dark greyish black, extremely fissile, noncalcareous, extremely micaceous, carbonaceous to coaly, very slightly silty.
46 - 52'	Interbedded sandstone and shale 75% sandstone - 25% shale
	SANDSTONE, as in the interval 41 - 46' except that the beds are thicker and more resistant, very finely laminated.
	SHALE, as in interval 41 - 46' except that it is fissile and extremely recessive, shales are not coaly.
52 - 66'	Shale with minor sandstone interbeds in the upper 5'. 97% shale - 3% sandstone
	SHALE, laminated medium-light-grey and light-olive-grey, weathers medium dark to dark grey, fissile, carbonaceous, silty, slightly calcareous, carbonaceous, micromicaceous.
	SANDSTONE, medium-light- and medium-dark-grey, weathers moderate brown and pale yellowish brown, very fine grained, thin-bedded, laminated, blocky, slightly calcareous, argillaceous, carbonaceous, micaceous, porosity (intergranular) poor to fair.
66 - 68'	SANDSTONE, medium- to dark-grey, weathers pale to moderate yellowish brown, very fine grained, very finely laminated, quartzitic, very slightly calcareous, micaceous, argillaceous and possibly slightly carbonaceous, porosity poor to nil.
68 - 69'6"	SHALE, dark-grey to greyish-black, weathers medium dark grey, fissile, slightly calcareous, carbonaceous, not sandy or silty.
69'6" - 72'	SANDSTONE, as in the interval 66 - 68' except perhaps this unit is somewhat darker and the laminae are not nearly as obvious as previously.
72 - 117'	Shale with minor platy to flaggy bands of sandstone.
	SHALE, greyish-black, weathers dark yellowish brown (?), fissile, no laminae, micaceous, carbonaceous, noncalcareous, sandy in places.

Interval	Description
	SANDSTONE BANDS, medium-light- and medium-dark-grey, mudstained to a dark yellowish brown, very fine to fine-grained, strongly laminated, carbonaceous and argillaceous, highly micaceous, slightly calcareous, porosity (intergranular) fair to poor.
117 - 144'	Sandstone with some minor shale interbeds 90% - 95% sandstone - 5% - 10% shale
	SANDSTONE, pale-brownish-grey, weathers moderate yellowish brown, very fine grained, thin- to medium-bedded, highly laminated and cross-bedded, slightly quartzitic, noncalcareous, argillaceous, micaceous, porosity (intergranular) is poor to nil.
	SHALE, black, weathers greyish black, fissile, recessive, extremely micaceous, coaly and carbonaceous, noncalcareous, not sandy or silty.
144 - 152'	Interbedded sandstone and shale 70% shale - 30% sandstone
	SHALE, greyish-black, weathers dark grey, fissile, recessive, carbonaceous, slightly calcareous and silty, highly micaceous.
	SANDSTONE, medium-olive-grey, weathers moderate brown, very fine to fine-grained, laminated, cross-bedded, noncalcareous, micaceous, argillaceous, slightly carbonaceous, porosity (intergranular) poor to fair.
152 - 155'	SANDSTONE, medium- to medium-dark-grey, weathers moderate yellowish brown, very fine grained, thin-bedded, no distinct laminae, slightly calcareous, carbonaceous (?), argillaceous, porosity (intergranular) poor to fair.
155 - 172'	Shale with minor sandstone bands near the base.
	SHALE, greyish-black, weathers dark grey, fissile, semi-recessive, no laminae, carbonaceous, micaceous, slightly silty to non-silty.
	SANDSTONE, medium-grey with dark-grey laminae, weathers pale yellowish brown, very fine grained, thin-bedded, laminated and finely cross-bedded, slightly calcareous, micaceous, argillaceous, slightly carbonaceous, porosity (intergranular) fair.

Interval	Description
172 - 183'	SANDSTONE, medium-olive-grey, weathers moderate yellowish brown, very fine grained, medium- to thick-bedded, not laminated, blocky to slabby, noncalcareous, partially quartzitic, slightly micaceous, contains dark carbonaceous patches, argillaceous, porosity (intergranular) fair to poor.
183 - 187'	Interbedded sandstone and shale 65% shale - 35% sandstone SHALE, dark-greyish-black, weathers medium to dark grey, fissile, recessive, contains fine-light-olive-grey and pale-yellowish-brown silty and sandy straight and curved laminae, noncalcareous, micaceous, silty and sandy, carbonaceous. SANDSTONE, light-greyish-brown, weathers dusky yellow, very fine grained, thin-bedded, flaggy to slabby, laminated and cross-bedded, noncalcareous, argillaceous, micromicaceous, partially quartzitic, porosity (intergranular) fair to poor.
187 - 210'	Interbedded sandstone and shale 70% - 75% sandstone - 25% - 30% shale SANDSTONE, medium-grey, weathers pale yellowish brown to light olive grey, very fine to fine-grained, thin- to medium-bedded, flaggy to blocky, excellent thin lamination and cross-bedding, partially quartzitic, contains small number of fine white quartz and red jasper pebbles, micromicaceous, argillaceous, porosity (intergranular) poor to nil. SHALE, greyish-black, weathers olive grey, fissile, slightly recessive, no laminae, micaceous, noncalcareous, carbonaceous, very slightly silty.
210 - 222'6"	SANDSTONE, medium- to medium-light-grey, weathers dark yellowish brown, fine-grained, thin- to medium-bedded, slabby to blocky, slightly calcareous, partially quartzitic, micromicaceous, slightly argillaceous, carbonaceous spots and patches present, porosity (intergranular) poor to nil.
222'6" - 238'	Interbedded sandstone and shale 55% - 60% sandstone - 45% - 40% shale SANDSTONE, medium-light-grey, weathers dark brownish grey, fine- to very fine grained, thin-bedded, slightly argillaceous, highly quartzitic, micromicaceous, slightly calcareous, porosity (intergranular) fair to poor.

Interval	Description
	SHALE, greyish-black, weathers dark grey to olive black, fissile, no laminae, micromicaceous, very slightly calcareous to noncalcareous, not sandy or silty.
238 - 251'	SANDSTONE, medium-grey to medium-olive-grey, weathers dusky yellow, very fine grained, thick-bedded, blocky, laminated and shows excellent fine cross-bedding, semi-conchoidal fracture, micaceous, slightly calcareous, partially argillaceous, porosity (intergranular) fair.
251 - 255'	Interbedded sandstone and shale 95% sandstone - 5% shale SANDSTONE, as in the unit above except that it is thin-bedded and has a flaggy to slabby breakage. SHALE, dark-grey, weathers dark olive grey, fissile, recessive, no laminae, highly micaceous, carbonaceous, noncalcareous.
255 - 258'	SANDSTONE, medium- to medium-dark-grey, weathers dusky yellow to moderate yellow brown, very fine grained, thick-bedded, blocky, slightly laminated, no cross-bedding, partially quartzitic, highly argillaceous, noncalcareous, some mica, porosity (intergranular) poor.
258 - 265'6"	Interbedded sandstone and shale 70% sandstone - 30% shale SANDSTONE, medium-dark-grey, weathers moderate brown, very fine grained, thin-bedded, flaggy to slabby, no laminae, highly quartzitic, noncalcareous, micaceous, argillaceous, porosity (intergranular) poor to nil. SHALE, dark-grey to greyish-black, weathers medium dark to olive grey, fissile, recessive with respect to sandstone, micaceous, carbonaceous, noncalcareous, not silty or sandy.
265'6"-272'6"	SANDSTONE, medium-light-grey, weathers dusky yellow and pale yellowish brown, very fine to fine-grained, thin- to medium-bedded, slightly quartzitic, argillaceous, micromicaceous, porosity (intergranular) poor to fair.
272'6"-284'6"	Interbedded sandstone and shale 65% - 70% sandstone - 35% - 30% shale SANDSTONE, light-grey and medium-dark-grey, weathers dusky yellow and moderate yellowish brown, very fine grained, laminated, highly quartzitic, very slightly calcareous, argillaceous, micromicaceous, porosity (intergranular) poor to nil.

Interval	Description
284'6"-291'	Interbedded sandstone and shale 55% shale - 45% sandstone SHALE, dark-grey, weathers medium dark grey to medium dark olive grey, extremely fissile, recessive, micromicaceous, noncalcareous, carbonaceous, not sandy or silty. SANDSTONE, medium-brownish-grey, weathers dark reddish brown, very fine grained, thin-bedded, very finely laminated, no cross-bedding, highly argillaceous, carbonaceous partings, slightly calcareous, micaceous, porosity (intergranular) fair.
291 - 304'	SANDSTONE, medium-brownish-grey, weathers dark yellowish orange, very fine grained, thick-bedded to massive, slightly laminated, highly argillaceous, micaceous, slightly calcareous, carbonaceous, pososity (intergranular) poor.
304 - 307'	Interbedded sandstone and shale 55% shale - 45% sandstone SANDSTONE, medium-grey, weathers light yellowish orange, very fine to fine-grained, medium-bedded, slabby to flaggy, finely laminated, argillaceous, noncalcareous, slightly carbonaceous (?), porosity (intergranular) fair to good. SHALE, dark-greyish-black, weathers medium dark grey and light olive brown, fissile, recessive, noncalcareous, micaceous, very slightly silty.
307 - 312'	SANDSTONE, light- to medium-light-grey, weathers light to medium brown, very fine grained, thick-bedded, slabby and blocky, very finely laminated, no cross-bedding, slightly calcareous, very slightly carbonaceous, argillaceous, porosity (intergranular) poor.
312 - 314'	SHALE, as in the interval 304 - 307'.
314 - 318'	Interbedded sandstone and silty shale 65% sandstone - 35% shale SANDSTONE, medium-dark- to dark-grey, weathers light to medium brown, very fine grained, thin-bedded, flaggy to platy, finely laminated, micaceous, argillaceous, carbonaceous, noncalcareous, porosity (intergranular) poor to nil. SHALE, black, weathers black and light dusk yellow, fissile becoming platy in sandier portions, carbonaceous, highly micaceous, noncalcareous, silty and sandy.

Interval	Description
318 - 325'	Interbedded sandstone and shale 65% - 70% sandstone - 30% - 35% shale SANDSTONE, medium-dark-grey, weathers dusky brown, very fine grained, (borders on siltstone) thin-bedded, flaggy, argillaceous, carbonaceous, micaceous, silty, noncalcareous, porosity (intergranular) nil to poor. SHALE, dark-blackish-grey, weathers moderate brown to greyish brown, fissile to platy, micaceous, silty, slightly calcareous, slightly carbonaceous.
325 - 343'	SHALE, as in the interval 318 - 325'.
343 - 345'	SANDSTONE, medium-dark-grey, weathers light to moderate brown, very fine grained, thick-bedded, slabby, ripple marks on the dip slopes, partially quartzitic (?), very slightly carbonaceous, noncalcareous, slightly micaceous, argillaceous, porosity (intergranular) poor to nil.
345 - 347'	SHALE, dark-greyish-black, weathers light to moderate brown and medium dark grey, crumbly to fissile, carbonaceous, micaceous, silty and sandy, noncalcareous.
347 - 351'	SANDSTONE, as in the interval 343 - 345'.
351 - 358'	Shale with minor sandstone interbeds. SHALE, black, weathers moderate brown and black, fissile to platy, recessive, carbonaceous (?), micaceous, noncalcareous, silty. SANDSTONE, dark- to medium-dark-grey, weathers moderate brown, fine-grained, medium- to thick-bedded, some suggestion of lamination, carbonaceous, micaceous, argillaceous, silty, porosity (intergranular) fair.
358 - 371'	SANDSTONE, medium- to medium-light-grey, weathers light whitish grey and light whitish brown, fine- to medium-grained, massive to thick-bedded, argillaceous, slightly micaceous, noncalcareous, noncarbonaceous, porosity (intergranular) poor.
371 - 379'	SHALE, black, weathers dark greyish black and dark reddish brown, recessive, carbonaceous, micaceous, noncalcareous, silty to sandy.

Interval	Description
379 - 386'	SANDSTONE, medium-dark-grey, weathers dark yellowish orange to light brown, fine-grained, massive to thick-bedded, blocky, some slickensiding perpendicular to the bedding, argillaceous, slightly micaceous, noncalcareous, slightly quartzitic (??), porosity (intergranular) poor.
386 - 391'	Interbedded sandstone and shale 55% - 60% sandstone - 40% - 45% shale SHALE, dark-grey, weathers black and moderate brown, extremely finely fissile, recessive, carbonaceous, micaceous, noncalcareous, not silty except in extreme basal and upper interbeds. SANDSTONE, medium-dark- to dark-grey, weathers dusky brown to moderate brown, very fine to fine-grained, medium-bedded, slabby and blocky, carbonaceous, argillaceous, noncalcareous, slightly silty, micaceous, porosity(intergranular) poor.
391 - 402'	SANDSTONE, medium-light-grey, weathers very pale orange and light brown, very fine to fine-grained, thick-bedded to massive, blocky, laminated, no cross-bedding or ripple marks, micaceous, slightly argillaceous, noncarbonaceous, porosity (intergranular) poor to nil.

This section was terminated at 402' because of an abrupt change in dip of the strata which is believed to be the result of major faulting. In addition, exposures beyond 402' are present but small and separated by large covered intervals.

Plate III

A. Mountain Park Railroad - Outcropping in a Canadian National Railroad cut near Mountain Park are approximately 300' of beds of the Nikanassin formation. These beds are reportedly overlain by a glauconitic sandstone unit (missing from photo at extreme left).

B. Mountain Park Railroad - Interbedded sandstones and shales of the Lower Nikanassin formation - note, these beds are almost identical lithologically with the uppermost Lower Nikanassin as exposed on Prospect Creek.

Plate IV

A. Mountain Park Railroad - View of the 0 - 180' interval of the M.P.R.R.-1 section of Nikanassin outcropping in a railway cut near Mountain Park - note contrast between prominent, partially quartzitic sandstone bands and less distinctive grey shale units.

B. Looking northeast down the McLeod River in the vicinity of section M.P.R.R.-1. From left to right, the beds exposed are; along the railroad the uppermost "Lower" Nikanassin; along the highway, "Lower" Nikanassin strata just above the boundary with the Passage Beds and Fernie shales just above the Rock Creek member.

Plate V

A. Mountain Park Railroad - Photo shows the stratigraphic interval from 250 - 300' below the glauconitic sandstone band of section M.P.R.R.-1 - note and compare the characteristics of the pale yellow sandstones with those thinner sandstone bands interbedded with shale.

B. Mountain Park Railroad - Photo was taken in a southerly direction from railroad track along which section M.P.R.R.-1 was measured, and shows the deformation present in the Nikanassin beds.

DESCRIPTION OF OUTCROP SECTIONS

SECTION: Mackenzie Creek-1-58
CODE: M.K.C.-1-58
FORMATION: Nikanassin Formation
LOCATION: Longitude: 117° 10' 30"
Latitude: 52° 56' 45"

Nikanassin-Cadomin Contact

The actual contact between the Nikanassin formation and the Cadomin conglomerate is concealed at this point.

Nikanassin Formation

Interval	Description
0 - 28'	Covered interval.
28 - 30'	SANDSTONE, dark-grey, weathers medium yellow brown, very fine grained, thin-bedded, finely laminated, no cross-bedding, highly calcareous, argillaceous, slightly silty, porosity (intergranular) poor.
30 - 38'	SANDSTONE, greyish-black, weathering pale-yellowish-brown, has dark greyish-black stains on the dip slope surfaces, very fine grained, thin-bedded, shingley, argillaceous, micaceous, calcareous, porosity (intergranular) poor.
38 - 45'	Poorly exposed interval - spot outcrops of sandstone as in interval 30 - 38'.
45 - 50'	SANDSTONE, medium-dark-grey, weathers a distinctive light brown, very fine to fine-grained, thick-bedded, cross-bedding evident, calcareous, argillaceous, slightly micaceous, porosity (intergranular) poor.
50 - 59'	SANDSTONE, medium-grey, weathers light olive grey to light grey, fine- to medium-grained, thin-to medium-bedded, platey, $\frac{1}{4}$" - $\frac{1}{2}$" crossbeds evident on weathered surface, argillaceous, micaceous, slightly silty, porosity (intergranular) poor.
59 - 62'	SANDSTONE, as above except for a number of clay ironstone nodules which are present here.
62 - 80'	SANDSTONE, medium-grey, weathers light olive grey to light grey (has a salt and pepper appearance), fine-grained, thin- to medium-bedded, flaggy to slabby, laminated, cross-bedded (1/8" and less), calcareous, argillaceous, micaceous, porosity (intergranular) poor.

Interval	Description
80 - 88'	SANDSTONE, dark-grey to grey-black, weathers pale to dark yellowish brown, fine- to medium-grained, medium- to thin-bedded, argillaceous, carbonaceous, micaceous, calcareous, porosity (intergranular) poor.
88 - 100'	SANDSTONE, medium-light-grey, weathers pale yellow brown to pale yellowish brown, very fine to fine-grained, thin-bedded, shingly, laminated, some cross-bedding, porosity poor to fair.
100 - 110'	SANDSTONE, dark-blackish-grey, weathers light brownish grey (has a salt and pepper appearance on weathered surface), fine-grained, thick-bedded, slabby, argillaceous, carbonaceous, slightly calcareous to noncalcareous, clay ironstone nodules present, poor porosity.
110 - 120'	SANDSTONE, medium-dark-grey, weathers medium dark olive grey and dark grey, fine- to medium-grained, medium-bedded, abundant shale chips give sandstone a "wafered" appearance, carbonaceous, argillaceous, porosity fair.
120 - 124'	SHALE, medium-grey, weathers medium grey to dark yellowish brown, platey to shingly, slight irregular lamellar markings, carbonaceous, slightly calcareous, micaceous and silty.
124 - 150'	SHALE, medium-light-grey, weathers medium brown grey, platey and chippy, recessive, laminated, cross-bedded, carbonaceous, micromicaceous, silty to sandy, calcareous.
150 - 175'	SHALE, dark-grey to grey-black, weathers dusky yellowish brown and dark brownish black, gradation of sand content is extremely well exemplified (increases upwards), silty in places, micaceous, slightly calcareous.
175 - 186'	SANDSTONE, dark-blackish-grey, weathers light grey and light grey brown, fine- to medium-grained, medium-bedded, black carbonaceous, slightly calcareous, argillaceous, no fossils, porosity (intergranular) poor.
186 - 210'	Interbedded sandstone and shaly siltstone 40% sandstone - 60% silty shale and shaly siltstone SANDSTONE, dark-blackish-grey, weathering pale-yellow-brown and light-grey-brown, fine-grained, medium- to thick-bedded, slabby, resistant, minor black carbonaceous laminae, highly calcareous, argillaceous, micaceous, porosity (intergranular) poor. SHALE and SILTSTONE, black, weathering dark-greyish-black, platey, recessive with respect to sandstone, noncalcareous, micaceous, carbonaceous, no fossils, porosity poor to nil.

Interval	Description
210 - 218'	SILTSTONE, dark-blackish-grey, weathers pale to moderate yellow brown, thin- to medium-bedded, platy to flaggy, sandy, slightly calcareous, minor micromica, carbonaceous, argillaceous, porosity (intergranular) poor to nil.
218 - 260'	Interbedded sandstone and sandy shale 65% - 60% sandstone - 35% - 40% shale SHALE, dark-grey to medium-dark-grey, weathers medium grey and dark grey brown, fissile to shingly and platy, laminated, no cross-bedding, silty and sandy, micromica abundant, slightly calcareous to noncalcareous, no fossils, porosity nil. SANDSTONE, medium-grey, weathers medium grey and medium grey brown, very fine grained, thin- to medium-bedded, flaggy to slabby, laminated, silty,highly argillaceous, carbonaceous, micaceous, very slightly calcareous, porosity (intergranular) poor.
260 - 290'	Shale with minor sandstone intercalations near top. SHALE, dark-grey-black, weathers dark grey and moderate yellow brown, fissile to chippy and shingly in sandy portions, laminated, carbonaceous, very slightly calcareous, micromicaceous, no fossils. SANDSTONE, dark-blackish-grey, weathers moderate yellow brown and light brown, fine- to very fine grained, thin-bedded, flaggy to slabby, laminated, carbonaceous, micaceous, porosity poor.
290 - 300'	Poorly exposed interval. SHALE, greyish-black, weathers dark grey, fissile to crumbly, recessive, no laminae or cross-bedding, noncalcareous, carbonaceous, clay.
300 - 314'	SHALE, dark-grey, weathers medium dark grey to dark grey, fissile to chippy, laminated, silty, micaceous, carbonaceous, very slightly calcareous, no fossils.
314 - 327'	Interbedded sandstone and shale 65% - 75% sandstone - 30% - 35% shale SANDSTONE, dark-grey, weathers pale yellow brown to light yellow brown, very fine grained, thin-bedded, slabby to flaggy, slightly calcareous, micaceous, argillaceous, carbonaceous, slightly silty, porosity (intergranular) poor.

Interval	Description
	SHALE, Medium-dark-grey to dark-grey, weathers medium dark grey, platy to shingly, laminated, carbonaceous, silty, micaceous, noncalcareous, porosity nil.
327 - 340'	SHALE, dark-blackish-grey, weathers dark grey and light brown, fissile, shingly in silty portions, laminated, micaceous, carbonaceous, slightly calcareous. Near the base, the shale becomes darker and chips of coal and black carbonaceous material are abundant.
340 - 345'	SILTSTONE, medium-grey, weathers pale to moderate yellow brown, medium- to thin-bedded, flaggy to slabby, wispy laminae, slightly calcareous, carbonaceous, micaceous, argillaceous, slightly sandy, porosity (intergranular) poor.
345 - 353'	SHALE, dark-greyish-black, weathers dark grey, shingly to platy, slightly recessive, laminated, carbonaceous, silty, slightly calcareous, micaceous.
353 - 355'	SILTSTONE, medium-grey, weathers light brown to pale yellow orange, medium-bedded, slabby, laminated, slightly calcareous to noncalcareous, micaceous, argillaceous, porosity (intergranular) poor.
355 - 372'	SHALE, dark-greyish-black, weathers dark grey and grey black, shingly to platy, silty, micromicaceous, slightly calcareous, carbonaceous.
372 - 374'	SILTSTONE, dark-blackish-grey, weathers light brown, medium-bedded, laminated, argillaceous, some carbonaceous partings, calcareous, micaceous, porosity poor.
374 - 436'	SHALE, dark-grey, weathers dark grey and grey black, crumbly to fissile, recessive, highly micaceous, slightly calcareous, carbonaceous, very slightly silty in upper portions.
436 - 440'	SANDSTONE, medium-dark-grey, weathers pale brown to pale yellow brown, fine- to very fine grained, medium- to thin-bedded, blocky, resistant, black bituminous and coal partings, highly micaceous, carbonaceous, slightly calcareous to noncalcareous, slightly silty, porosity (intergranular) poor.
440 - 460'	Interbedded sandstone and shale 55% sandstone - 45% shale SANDSTONE, Medium-dark-grey to dark-grey, weathers medium dark grey, very fine grained, thin-bedded, flaggy to platy, laminated, carbonaceous, slightly calcareous, argillaceous, micaceous, porosity (intergranular) poor.

Interval	Description
	SHALE, dark-blackish-grey, weathers dark grey to blackish grey, shingly, laminated, recessive, carbonaceous, micaceous, noncalcareous.
460 - 468'	SANDSTONE, medium-dark to dark-grey, weathers medium dark grey, fine-grained, thin-bedded, flaggy to slabby, laminated, very slightly calcareous, carbonaceous, silty, micaceous, argillaceous, porosity (intergranular) poor.
468 - 485'	SHALE, dark-grey-black, weathers dark grey black, shingly to platy, recessive, laminated, carbonaceous, micaceous, noncalcareous, slightly silty, no fossils.
485 - 490'	Interbedded sandstone and shale 75% - 80% sandstone - 25% - 20% shale
	QUARTZITIC SANDSTONE, medium-grey, weathers brownish black, very fine grained, medium- to thin-bedded, slabby to thick platy, very slightly calcareous to noncalcareous, argillaceous, quartzitic, micaceous, carbonaceous, porosity (intergranular) nil to poor.
	SHALE, dark-grey, weathers dark grey and grey black, platy to shingly, recessive, highly sandy and silty, carbonaceous, micaceous, noncalcareous, no fossils.
490 - 510'	Interbedded sandstone and shale 60% sandstone - 40% shale
	SANDSTONE, medium-dark-grey, weathers medium grey and pale yellow brown, fine- to very fine grained, medium- to thin-bedded, blocky to slabby, slightly calcareous, argillaceous, carbonaceous, micaceous, porosity (intergranular) poor to fair.
	SHALE, medium-grey to dark-blackish-grey, weathering dark-grey, shingly to fissile, recessive, no laminae or cross-beds, carbonaceous, micaceous, slightly silty, noncalcareous.
510 - 514'	SHALE, dark-blackish-grey, weathering dark-grey, fissile, recessive, very slightly silty, very slightly calcareous to noncalcareous, micaceous, carbonaceous, no fossils.
514 - 519'	Interbedded sandstone and shale 65% - 70% sandstone - 30% - 35% shale
	SANDSTONE, medium-dark-grey, weathers medium light grey, very fine grained, thin-bedded, platy to flaggy, carbonaceous, silty, noncalcareous, argillaceous, micaceous (?), porosity (intergranular) poor to nil.

Interval	Description
	SHALE, medium-dark-grey, weathering medium-grey, shingly to platy, laminated, silty, carbonaceous, noncalcareous, micaceous.
519 - 522'	SHALE, as above.
522 - 535'	Interbedded sandstone and shale 70% - 75% sandstone - 30% - 25% shale SANDSTONE, medium- to medium-dark-grey, weathers light brownish grey to pale yellow brown, very fine grained, thin- to medium-bedded, flaggy and platy, black carbonaceous partings present, argillaceous, micaceous, slightly calcareous, porosity (intergranular) poor to nil. SHALE, dark-greyish-black, weathers dark grey, chippy to shingly, slightly recessive, micaceous, noncalcareous, carbonaceous.
535 - 550'	SHALE, dark-grey to grey-black, weathers dusky yellow to dark grey, fissile to crumbly, recessive, laminated in basal portions, silty in lower part, carbonaceous, noncalcareous, micaceous, porosity poor to nil.
550 - 559'	SANDSTONE, medium-light-grey, weathering medium- to medium-light-grey, fine- to very fine grained, medium-bedded, slabby to blocky, no laminae or cross-beds, very slightly calcareous, argillaceous, slightly carbonaceous, micaceous, porosity (intergranular) poor to fair.
559 - 568'	Interbedded sandstone and shale 65% - 70% shale - 30% - 35% sandstone SHALE, dark-greyish-black, weathers dark grey, fissile to chippy and shingly, very slightly recessive, some silty laminae, carbonaceous, micaceous, calcareous. SANDSTONE, medium-light- to medium-grey, weathering dark-yellow to moderate-yellow-brown, fine-grained, thin-bedded, flaggy to slabby, highly laminated, argillaceous, slightly carbonaceous, silty, micaceous, very slightly calcareous, porosity (intergranular) poor.
570 - 585'	SHALE, dark-grey-black, weathering pale-brown to brownish-grey, shingly to fissile, noncalcareous, carbonaceous, micaceous, some black bituminous coal partings are present.

Interval	Description
585 - 588'	SHALY SILTSTONE, medium-dark-grey, weathers dark yellowish orange, medium- to thick-bedded, resistant, numerous black carbonaceous partings, highly argillaceous, very slightly calcareous to noncalcareous, micaceous, carbonaceous, porosity poor to nil.
588 - 590'	SHALE, black, weathers black, fissile, recessive, highly carbonaceous, coaly, micaceous, noncalcareous, porosity nil.
590 - 593'	SANDSTONE, medium-dark-grey, weathers medium light grey, very fine grained platy to shingly, laminated, silty, carbonaceous, argillaceous, micaceous, noncalcareous, porosity (intergranular) poor to nil.
593 - 600'	SANDSTONE, medium-light-grey, weathers light olive grey, very fine grained, thin- to medium-bedded, slabby, laminated, argillaceous, slightly carbonaceous, very slightly calcareous, micaceous, porosity (intergranular) poor.
600 - 619'	Interbedded silty shale and sandstone.
	SANDSTONE, medium-light- to medium-grey, weathering pale-yellowish-brown, very fine grained, thin-beded, platy to flaggy, irregular dark grey partings and lamellar markings, argillaceous, very slightly carbonaceous, very slightly calcareous, porosity (intergranular) poor.
	SHALE, medium-dark and medium-light-grey, weathering medium-dark-grey, shingly, slightly recessive, laminated, silty, sandy, very slightly calcareous, highly micaceous, carbonaceous.
619 - 630'	SHALE, black, weathering dark-grey-black, fissile, recessive, fine laminae, no cross-bedding, carbonaceous, very slightly silty, very slightly calcareous, minor micromica.
630 - 637'	Interbedded silty sandstone and silty shale 55% - 60% sandstone - 45% - 40% shale
	SANDSTONE, medium-dark-grey to dark-grey, weathering light-olive-grey, very fine grained, thin- to medium-bedded, platy to slabby, highly laminated, no cross-bedding, highly micaceous, noncalcareous, silty, carbonaceous, argillaceous, porosity (intergranular) poor.
	SHALE, dark-grey-black, weathering dark-grey, platy, recessive, laminated, silty, carbonaceous, micromicaceous, noncalcareous.

Interval	Description
637 - 642'	SANDSTONE, medium-grey to medium-light-grey, weathering light-brownish-grey to olive-grey, fine-grained, medium- to thick-bedded, faint wispy laminae, argillaceous, very slightly calcareous, noncarbonaceous, slightly silty, micaceous, porosity (intergranular) poor to nil.
642 - 650'	Poorly exposed interval of Interbedded sandstone and shale 85% - 90% shale - 10% - 15% sandstone SHALE, dark-grey-black, weathering light-olive-grey, slabby to platy, recessive, no laminae, highly carbonaceous, not sandy or silty, highly calcareous, minor micromica. SANDSTONE, as in interval 640 - 642'.
650 - 675'	Shale with minor interbeds of siltstone 2% - 5% siltstone SHALE, dark-grey to grey-black, weathers dark grey black, thin platy to shingly, recessive, some very fine laminae, carbonaceous, very slightly silty, some minor micromica, noncalcareous. SILTSTONE, medium-dark-grey, weathers light to moderate brown, thin-bedded, flaggy to thick platy, fine laminae, carbonaceous, highly argillaceous, very slightly calcareous, micromicaceous, porosity poor.
675 - 687'	Interbedded shale and shaly siltstone 60% shale - 40% siltstone SHALE, black, weathering light-olive-grey, very slightly recessive, carbonaceous, slightly silty, very slightly calcareous, micaceous, porosity nil. SILTSTONE, as in interval 650 - 675'.
687 - 710'	SHALE, dark-blackish-grey, weathering medium-dark-grey and pale-brown, fissile to chippy, slight suggestion of laminae, carbonaceous, very slightly calcareous, micaceous.
710 - 718'	Covered interval.
718 - 733'	Interbedded sandstone and shale 55% - 60% sandstone - 40% - 45% shale

Interval	Description
	SANDSTONE, medium- to medium-light-grey, weathering medium-light-grey and pale-yellow-brown, very fine to fine-grained, medium-bedded, slabby to blocky, irregular black carbonaceous markings, ripple markings evident, slightly calcareous, minor micromica, porosity (intergranular) poor to nil.
	SHALE, dark-greyish-black, weathering dark-grey and brownish-grey, thin platy, recessive, no laminae, carbonaceous, partings are numerous, very slightly calcareous, micaceous (?), silty.
733 - 740'	SANDSTONE, medium-dark-grey, weathers medium light grey and pale yellow brown, very fine to fine-grained, medium- to thick-bedded, slabby to blocky, laminated, carbonaceous, silty, noncalcareous, micaceous. porosity (intergranular) poor to nil.
740 - 750'	Poorly exposed interval.
	SHALE, dark-grey, weathering medium-dark to dark-grey, fissile to crumbly and chippy, recessive, carbonaceous, very slightly silty, noncalcareous, minor micromica.
750 - 760'	SANDSTONE, medium-dark-grey to brownish-grey, weathers pale brown to brownish grey, very fine to fine-grained, medium- to thick-bedded, slabby, highly argillaceous, micromicaceous, very slightly calcareous to noncalcareous, carbonaceous, silty, porosity (intergranular) poor.
760 - 765'	SHALE, grey-black, weathering dark-grey, fissile, recessive, highly carbonaceous, micromicaceous, noncalcareous, not silty.
765 - 769'	SANDSTONE, medium-grey to medium-dark-grey, weathers medium light to light olive grey, and pale yellow brown, very fine grained, thin- to medium-bedded, flaggy, some minor laminae, silty, carbonaceous, slightly calcareous, argillaceous, porosity (intergranular) poor.
769 - 780'	SHALE, dark-grey, fissile, recessive, carbonaceous, micaceous, noncalcareous, not silty.
780 - 795'	Shale with minor sandstone intercalations.
	SHALE, as above 769 - 780'.
	SANDSTONE, medium-light-grey, weathers pale to moderate yellow brown, very fine grained, thin- to medium-bedded, slabby, laminated, very fine cross-bedding, silty, micaceous, argillaceous, very slightly calcareous, porosity (intergranular) poor.

Interval	Description
795 - 798'	SANDSTONE, dark-grey, weathers dark yellow orange, very fine grained, thin-bedded, platy to flaggy, highly micaceous, carbonaceous, silty, argillaceous, slightly calcareous, porosity (intergranular) poor.
798 - 804'	SHALE, medium-dark-grey, weathers medium dark grey to brownish grey, fissile, recessive, carbonaceous, micromicaceous, very slightly calcareous, very slightly silty.
804 - 818'	SANDSTONE, medium-grey, weathers medium grey to olive grey, fine- to medium-grained, medium- to thin-bedded, slabby, argillaceous, noncarbonaceous, micaceous, noncalcareous, porosity (intergranular) poor to fair.
818 - 820'	Interbedded sandstone and shale 60% shale - 40% sandstone SHALE, dark-grey to grey-black, weathers dark grey, fissile, no laminae, no cross-bedding, carbonaceous, not sandy or silty, highly micaceous, noncalcareous. SANDSTONE, medium- to olive-grey, weathers light grey to yellowish grey, very fine grained, thin-bedded, platy to flaggy, laminated, silty, argillaceous, micaceous, noncalcareous, porosity (intergranular) poor.
820 - 850'	Covered interval.
850 - 855'	SANDSTONE, medium-light to olive-grey, weathers moderate brown and light grey, fine-grained, thin- to medium-bedded, slabby to flaggy, argillaceous, micaceous, silty, very slightly calcareous, porosity (intergranular) poor.
855 - 879'	Shale with minor sandstone intercalations. SHALE, dark-greyish-black, weathers brownish grey and medium dark grey, fissile, recessive, micaceous, noncalcareous, carbonaceous. SANDSTONE, as in interval 850 - 855'.
879 - 884'	SANDSTONE, dark-yellowish-brown to light-olive-grey, weathers pale olive to dusky yellow, fine-grained, medium- to thin-bedded, slabby to flaggy, highly laminated, simple straight cross-bedding, highly argillaceous, micaceous, slightly silty, very slightly calcareous, porosity (intergranular) poor to fair.

Interval	Description
884 - 895'	Shale with some minor sandstone intercalations. SHALE, black, weathers black, fissile, slightly recessive, carbonaceous, highly micaceous, not sandy or silty, noncalcareous, no fossils. SANDSTONE, as in interval 879 - 884'.
895 - 901'	SANDSTONE, medium-light to medium-grey, weathers light brown and brownish grey, very fine grained, medium- to thick-bedded, slabby to blocky, highly laminated, silty, highly micaceous, noncalcareous, argillaceous, carbonaceous in part, porosity (intergranular) poor.
901 - 908'	Interbedded sandstone and shale 65% - 70% sandstone - 30% - 35% shale SANDSTONE, medium- to dark-grey, weathers light olive grey, very fine grained, medium- to thick-bedded, slabby to irregular blocky, slightly carbonaceous, silty, noncalcareous, argillaceous, porosity (intergranular) poor to nil. SHALE, black, weathers dark greyish black and light brown, fissile, recessive, highly micaceous, carbonaceous, not sandy or silty, noncalcareous.
908 - 920'	SHALE, black, weathers black, fissile, slightly recessive, carbonaceous, highly micaceous, noncalcareous, not sandy or silty.
920 - 924'	SANDSTONE, medium-light to medium-grey, weathers pale yellow brown to light olive grey, very fine to fine-grained, medium-bedded, slabby to flaggy, carbonaceous in parts, argillaceous, micaceous, very slightly calcareous, porosity (intergranular) poor to fair.
924 - 935'	SHALE, black, weathers black and moderate brown, fissile, carbonaceous, highly micaceous, not sandy or silty, noncalcareous.
935 - 957'	SANDSTONE, light-grey with some medium-dark-grey laminae, weathers light olive to pale yellowish brown, fine- to medium-grained, medium- to thin-bedded, slabby, laminated, some mica, noncalcareous to very slightly calcareous, porosity (intergranular) fair.
957 - 963'	SANDSTONE, medium-grey, weathers pale to moderate yellow brown, fine- to medium-grained, medium-bedded, slabby to flaggy, carbonaceous and coaly partings, argillaceous, some mica, very slightly calcareous, porosity (intergranular) fair to poor.

Interval	Description
963 - 970'	SANDSTONE, medium-brownish-grey, weathers medium dark grey and dark yellowish orange, fine- to very fine grained, massive to thick-bedded, argillaceous, slightly carbonaceous, some mica, noncalcareous, porosity (intergranular) fair.
970 - 992'	Shale with minor sandstone intercalations.
	SHALE, dark-grey to blackish-grey, weathers dark grey and light brown to moderate brown, fissile, recessive, micaceous, carbonaceous, noncalcareous, not silty or sandy.
	SANDSTONE, medium- to medium-dark-grey, weathers pale yellow brown, very fine to fine-grained, thin-bedded, slabby to flaggy, finely laminated, argillaceous, very slightly calcareous, carbonaceous, micaceous, porosity (intergranular) poor.
992 - 1000'	SANDSTONE, medium-grey, weathers moderate yellow to pale yellow brown, fine- to very fine grained, medium-bedded, highly resistant, carbonaceous, argillaceous, very slightly calcareous, micromicaceous, porosity (intergranular) poor to nil.
1000 - 1025'	Shale with minor sandstone intercalations near the top.
	SHALE, dark-black, weathers black and moderate to light brown, fissile, recessive, carbonaceous, highly micaceous, noncalcareous, not sandy or silty.
	SANDSTONE, medium-grey, weathers dark grey to light brown, very fine to fine-grained, thin-bedded, slabby, black carbonaceous partings, numerous, argillaceous, noncalcareous, silty in part, micaceous, porosity (intergranular) poor.
1025 - 1064'	Poorly exposed interval - spot outcrops of black shale.
1064 - 1073'	Interbedded sandstone and shale 55% sandstone - 45% shale
	SANDSTONE, medium-dark-grey, weathers moderate brown, fine-grained, medium- to thick-bedded, no laminae or cross-bedding, carbonaceous, argillaceous, micaceous, noncalcareous, porosity (intergranular) poor.
	SHALE, dark-greyish-black, weathers dark grey and dark reddish brown, fissile, recessive, carbonaceous, highly micaceous, not silty.

Interval	Description
1073 - 1090'	SANDSTONE, light-grey to medium-light-grey, weathers medium dark grey to moderate brown and moderate yellowish brown, fine-grained, medium- to thick-bedded, slabby, slight lamination and faint cross-bedding, ripple marks evident, slightly argillaceous, micaceous, noncalcareous, porosity (intergranular) fair to poor.
1090 - 1100'	Interbedded sandstone and shale 65% - 70% shale - 30% - 35% sandstone SHALE, black, weathers greyish brown and dark greyish black, fissile to crumbly, recessive, carbonaceous, not silty or sandy, micaceous, noncalcareous. SANDSTONE, medium-dark-grey to dark-grey, weathers pale yellow brown, very fine to fine-grained, thin-bedded, slabby to platy, faint fine laminae, carbonaceous, highly argillaceous, silty, noncalcareous, porosity (intergranular) good.
1100 - 1102'	SANDSTONE, medium-light-grey, weathers light brown and light olive grey, fine- to very fine grained, no laminae or cross-bedding, noncarbonaceous, argillaceous, micromicaceous, slightly calcareous, porosity (intergranular) poor.
1102 - 1126'	Poorly exposed interval of Interbedded sandstone and shale 55% - 65% shale - 45% - 35% sandstone SANDSTONE, medium-dark-grey, weathers pale yellow brown to light olive grey, very fine grained, medium-bedded, no laminae or cross-bedding, micaceous, carbonaceous, argillaceous, noncalcareous, porosity (intergranular) poor. SHALE, dark-brownish-grey to brownish-black, weathers dark grey and moderate yellow brown, fissile to crumbly, micaceous, silty in upper portions, noncalcareous, carbonaceous.
1126 - 1137'	Interbedded sandstone and shale 70% - 75% sandstone - 30% - 25% shale SANDSTONE, medium-grey, weathers dusky yellow to moderate yellow brown, very fine to fine-grained, medium- to thick-bedded, blocky to slabby, some very faint laminae, no cross-bedding, micaceous, carbonaceous, noncalcareous, slightly silty, porosity (intergranular) poor. SHALE, medium-grey to medium-dark-grey, weathers dark grey and medium yellow brown, chippy to shingly, no laminae, highly silty, carbonaceous, micaceous, noncalcareous.

Interval	Description
1137 - 1141'	Shale with minor interbeds of silty sandstone. SHALE, black, weathers black and dark reddish brown, fissile, recessive, some fine laminae present, silty, carbonaceous, micaceous, noncalcareous. SANDSTONE INTERBEDS, medium-light-grey, weathering medium-grey and light-olive-grey, very fine to fine-grained, thin-bedded, highly cross-bedded on a very fine scale, argillaceous, micaceous, noncalcareous, porosity (intergranular) poor.
1141 - 1149'	SANDSTONE, medium-grey, weathers brownish grey and moderate brown, fine-grained, medium- to thick-bedded, blocky, faint dark grey laminae, noncalcareous, slightly argillaceous, slightly carbonaceous, some minor micromica, porosity (intergranular) poor.
1149 - 1151'	Shale with minor sandstone interbeds Sandstone - 10% of interval SHALE, dark-grey, weathers dark grey and blackish red, crumbly, slightly recessive, not sandy or silty, slightly carbonaceous, micaceous, iron stained (?). SANDSTONE INTERBEDS, as in interval 1141 - 1149', except is perhaps somewhat quartzitic.
1151 - 1159'	Covered interval.
1159 - 1161'	SANDSTONE, medium-dark-grey, weathers light olive grey to dusky yellow, fine- to very fine grained, thin- to medium-bedded, slabby, highly laminated, no signs of cross-bedding, micaceous, argillaceous, slightly calcareous, carbonaceous, porosity (intergranular) poor.
1161 - 1169'	Interbedded sandstone and shale 70% - 75% shale - 25% - 30% sandstone SANDSTONE, dark-grey, weathers pale yellowish to greyish brown, fine- to very fine grained, medium-bedded, resistant, some suggestion of very faint lamination, no cross-bedding, carbonaceous, argillaceous, very slightly calcareous, porosity (intergranular) poor. SHALE, medium-dark-grey to dark-grey, weathers medium dark grey and greyish brown, fissile, some minor lamination evident, sandy in lower portions, carbonaceous, micaceous, noncalcareous.

Interval	Description
1169 - 1181'	Covered interval.
1181 - 1189'	Poorly exposed interval of SANDSTONE, medium-light to light-olive-grey, weathers light olive to light yellowish grey and pale yellowish brown, very fine grained, thin-bedded, platy, laminated on weathered surface, very slightly calcareous, carbonaceous, slightly argillaceous, porosity (intergranular) poor to nil.
1189 - 1208'	Covered interval.
1208 - 1247'	Interbedded sandstone and shale 55% - 60% sandstone - 40% - 45% shale SANDSTONE, medium-dark-grey, weathers brownish grey, very fine to fine-grained, thick- to medium-bedded, resistant, blocky, highly laminated, carbonaceous, argillaceous, minor micromica, noncalcareous, porosity (intergranular) poor. SHALE, dark-grey to medium-grey, weathers medium to olive grey, fissile to crumbly, recessive, no laminae, micromica, noncalcareous, carbonaceous, slightly silty to sandy.
1247 - 1264'	Shale with minor interbands of sandstone 75% - 80% shale - 20% - 25% sandstone SANDSTONE, dark-yellowish-brown, weathers pale brown to pale yellowish brown, very fine grained, thin-bedded, platy, slightly resistant, no laminae or cross-bedding, micromicaceous, argillaceous, noncarbonaceous, very slightly calcareous, porosity (intergranular) poor; SHALE, dark-grey, weathers dark yellowish brown and pale brown, fissile, recessive, no laminae or cross-bedding, carbonaceous, micaceous, noncalcareous, slightly silty to sandy.
1264 - 1265'	SANDSTONE, light-grey, weathers light olive grey, fine- to medium-grained, medium- to thin-bedded, slabby, resistant, calcareous, nonargillaceous, noncarbonaceous, some minor mica, porosity (intergranular) poor.

At 1265' a fault terminates the continuous outcrop of the Nikanassin formation.

Plate VI

A. Mackenzie Creek - Shown is a small outcrop of the Upper Nikanassin formation on the extreme left; a 28' covered interval which represents the uppermost Nikanassin beds and a portion of the 55' thick Cadomin conglomerate (extreme right).

B. Mackenzie Creek - Stratigraphic interval represented begins at approximately 180' (extreme right), and extends downstream to 310' below the Cadomin conglomerate - note the recessive nature of the interbeds of shale, and also the platy to slabby, pale-orange and medium-light-grey resistant sand and siltstone units. Shales are becoming more noticeably abundant after 265'.

Plate VII

A. Mackenzie Creek - Portion of section shown represents approximately the interval from 350 - 435' below the top - note dark grey shales predominate and are broken only occasionally by 2 - 3' bands of pale yellowish orange weathering siltstone.

B. Mackenzie Creek - View looking south-southeast up Mackenzie Creek illustrates general outcrop character of shaly interval from approximately 320 - 460' below the Cadomin conglomerate.

Plate VIII

A. Mackenzie Creek - Prominent gulley (left centre) is the expression of the fault which terminates the Nikanassin formation at 1265'. The fault dips 47° SW (to the right) and rises higher in the section as the gulley proceeds up the hill. The beds to the left of the gulley are Nikanassin strata repeated

B. Mackenzie Creek - Close-up view of fault gulley illustrated in A. - note the dead white tree trunk in upper left hand corner which points directly at the gouge zone of the fault.

DESCRIPTION OF OUTCROP SECTIONS

SECTION: Prospect Creek-1-58
CODE: P.P.C.-1-58
FORMATION: Nikanassin Formation
LOCATION: Longitude: 117° 20' 00"
Latitude: 52° 57' 15"

That portion of the Nikanassin formation measured at P.P.C.-1-58 consists of 59' of interbedded sandstones and shales directly above the Nikanassin-Passage Bed contact.

Nikanassin-Passage Bed Contact

Although subject to some personal interpretation, the Nikanassin-Passage Bed contact on Prospect Creek is placed at the change in the sandstone-shale ratio - that is, above the break, sandstone interbeds predominate over shales and these beds are assigned to the Nikanassin formation. Contrastingly, below the contact, the Passage Beds carry a predominance of shales over sandstones.

On Prospect Creek, this gradational contact is perfectly exposed.

Nikanassin Formation

Interval	Description
0 - 55'	Interbedded sandstone and shale 70% - 75% sandstone - 30% - 25% shale SANDSTONE, medium-grey, weathers light brown to dark yellowish orange, very fine grained, medium-bedded, blocky to slabby, very finely laminated, no signs of cross-bedding, highly argillaceous, silty, micaceous, noncalcareous, slightly carbonaceous (?), slightly quartzitic (?), porosity (intergranular) poor. SHALE, dark-yellowish-brown to light-olive-grey, weathers pale yellowish to moderate yellowish brown, fissile to chippy, slightly recessive, darker carbonaceous material becomes more abundant towards the base, highly micaceous, carbonaceous, silty, noncalcareous.
55 - 59'	Sandstone with minor shale partings. SANDSTONE, medium-dark-grey, weathers dark yellowish orange to light brown, very fine grained, medium- to thick-bedded, blocky, no laminae or cross-beds, argillaceous, micaceous, slightly carbonaceous (?), calcareous, porosity (intergranular) poor.

Plate IX

A. Prospect Creek - Exposure of proposed contact between the Nikanassin formation and the "Passage Bed" equivalents of the Fernie Group. Fine bright orange line to the right of the centre of the photograph marks the break between the two units.

B. Prospect Creek - Close-up view of same contact as described in A. - note the orange line once again which marks a rather distinct lithologic break. The sandier Nikanassin beds outcrop on the left and the more fissile shaly "Passage Bed" equivalents on the right.

CHAPTER FOUR

PALAEONTOLOGY

In this study, both the micro- and mega-palaeontological aspects of the Nikanassin formation of the type area are considered. The shale interval used for microfaunal investigation collected by the author, is described and photographed in Appendix C. The megafossils examined were provided by the Department of Geology from collections made by Drs. P.S. Warren and C.R. Stelck. Faunal and floral localities also appear in Appendix C.

MICROPALAEONTOLOGY

Preparation of Samples

The shales checked for microfossils were prepared by the author as follows: about ½ to 3/4 of each shale sample was placed in ordinary tap water for a period of three weeks. The shale was then washed through a series of 8" Tyler screens consisting of the following mesh sizes; 16, 45, 60, 80, and 100. The portion of the sample which washed through the 100 screen was collected in a pan, inspected for Radiolarians and similar other minute forms, and discarded. The residues retained on each of the other screens were decanted into a saucer, dried, concentrated using a Franz Isodynamic Separator (Peterson, 1958), and bottled.

The high silt content of the shales made disintegration by ordinary water slaking very slow. Thus, in an attempt to accelerate the disintegration process, a technique, described by Kirchner (1958), was

modified to increase the rate of disintegration of the shale samples. Standard picking procedure followed.

The yield was poor and only generic determinations are available. However, the following assemblage was obtained:

Haplophragmoides sp. indet.

Ammobaculites sp. indet.

Nodosaria sp. indet.

Verneulina sp. indet.

Unidentifiable organic spheres.

MEGAPALAEONTOLOGY

The fossil fauna and flora used in this investigation of type Nikanassin formations were photographed and are presented in Plate 13.

Formal Descriptions

Phylum SPERMATOPHYTA

Class GYMNOSPERMAE

Order GINKGOALES

Genus GINKGO Linnaeus

Ginkgo cf. *G. nana* Dawson

Plate 13, Fig. 4.

Salisburia (*Ginkgo*) *sibirica* Dawson (non Heer), 1885, Roy. Soc. Canada, Trans., Vol. 3, sec. 4, p. 8, Pl. 2, fig. 1 (1886).

Salisburia (*Ginkgo*) *lepida* Dawson (non Heer), ibid., p. 8, Pl. 2, fig. 2 (1886).

Salisburia (*Ginkgo*) *nana* Dawson, ibid., p. 8, Pl. 2, fig. 3 (1886).

Baiera longifolia Dawson (non Heer), ibid., p. 9, Pl. 2, fig. 5 (1886).

Ginkgo arctica Berry pars, Nat. Mus Canada Bull. 58, p. 49, Pl. 7, fig. 6 (1929).

Ginkgo nana Bell, 1956, Lower Cretaceous Flora of Western Canada, Geol. Surv. Canada, Mem. 285, p. 86, Pl. 37, fig. 4.

Flabelliform, petiolate leaves, blade is dissected by two and possibly four dichtomies into elongate segments that taper distally to rounded apices; ultimate segments generally 3 to 6 mm. broad. Veins faint, sub-parallel convergent at the apex. Length of blade varies from 25 to 40 mm.

Hypotype locality - Villeneuve Creek, 70 feet below the Cadomin conglomerate.

Hypotype - Geol. Mus. Coll., University of Alberta

Remarks

The type specimen consist of a mere fragment of an abnormal leaf and has 4 or 5 veins to a segment. In this respect, as well as dimension-wise, the hypotype is comparable with the type fossil.

Order CONIFERALES

Genus PITYOPHYLLUM

Pityophyllum cf. P. nordenskioldi Heer

Plate 13, Fig. 5.

Pityophyllum nordenskioldi Heer, 1876, Flora fossilis arctica, Vol. 4, pt. 1, p. 45, Pl. IX, figs. 1-6; idem, pt. 2, pp. 76, 117, Pl. IV, fig. 8c; Pl. XX, fig. 4a, b; Pl. 27, fig. 9a; Pl. 28, fig. 4.

Pinus (Cyclopitus) nordenskioldii Dawson, 1892, Roy. Soc. Canada,

Trans. Vol. 10, sec. 4, p. 88, text fig. 9 (1893).

Oleandra graminaefolium Berry (non Knowlton), 1929, Nat. Mus. Canada

Bull. 58, p. 38, Pl. 5, fig. 5 (non-fig. 6).

Pityophyllum cf. nordenskioldi Bell, 1956, Lower Cretaceous Flora of

Western Canada, Geol. Surv. Canada, Mem. 285, p. 112,

Pl. 61, fig. 3; Pl. 62, figs. 1, 4, 5.

Detached, linear, uninerved leaves, 1 to 3 mm. wide and up to 60 mm. long, straight or curved, gradually contracted to base and rather sharply to an acute apex. Mid-rib rather faint on most specimens. Surface Marked by microscopic longitudinal striae and numerous close transverse wrinkles that resemble lateral veins.

Hypotype locality - Villeneuve Creek, 70 feet below the Cadomin conglomerate.

Hypotype - Geol. Mus. Coll., University of Alberta.

Remarks

Upon megascopic inspection the hypotype appears to be rather featureless; however, upon observation with hand lens (x10), the ribs and wrinkles become distinguishable.

Incertae sedis

Genus PODOZAMITES C.F.W. Braun

Podozamites cf. P. lanceolatus (Lindley and Hutton) C.F.W. Braun.

Plate 13, Fig. 4.

Zamites lanceolata Lindley and Hutton, 1836, the fossil flora of Great Britain, Vol. 3, p. 121, Pl. 194, London.

Podozamites lanceolatus (Lindley and Hutton) C.F.W. Braun, 1843, in Munster, Beitrage zur Petrefacten-Kunde, Vol. 2, No. 6, p. 33, Bayreuth.

Podozamites lanceolatus Dawson, 1885, Roy. Soc. Canada, Trans., Vol. 3, sec. 4, p. 6, Pl. 1, fig. 3 (1886).

Podozamites lanceolatus Berry, 1929, Nat. Mus., Canada, Bull. 58, p. 45, Pl. 6.

Nageiopsis zamioides Berry (non Fontaine), 1929, op. cit. p. 49.

Podozamites latipennis Berry (non Heer), 1929, op. cit. p. 59.

Podozamites lanceolatus Bell, 1956, Lower Cretaceous Flora of Western Canada, Mem. 285, p. 123, Pl. 72, fig. 3; Pl. 73, fig. 2.

Single leaf, 4.5 cm long, 5 mm. wide, lanceolate, blunt, expanded basal end and more gradually tapered or pointed at the apex. Veins subparalled and only faintly distinguishable near the base and apex. No striae identifiable.

Hypotype locality - Villeneuve Creek, collected 70 feet below the Cadomin conglomerate.

Hypotype - Geol. Mus. Coll., University of Alberta.

Remarks

The specimen described is similar to most species represented in that it is a singular, detached leaf. Neither the axis nor the point of attachment is present.

Phylum MOLLUSCA

Class PELECYPODA

Sub Class PRIONODESMACEA

Order SCHIZODONTA

Super Family PTERINACEA

Genus AUCELLA **Keyserling** 1843

Aucella cf. A. mosquensis Von Buch.

Plate 13, Figs. 1 and 3.

Not Aucella mosquensis (Von Buch), Keyserling, nor Lahusen.

Avicula mosquensis Von Buch, 1844, Neues Jahrb. f., Min. Geol. und Paleont., p. 537, Pl. 4, fig. 1.

Aucella mosquensis Lindstrom, 1866, Om Tria-och Jura forst. fran Spetsbergen, Pl. 3, fig. 3.

Aucella mosquensis (Von Buch) Pavlow, 1907, p.22, Pl. 2, figs. 5a-c; 6a-c; 7a, b; 8.

Aucella aff. A. mosquensis Anderson, 1945, Bull., Geol. Soc. America, Vol. 56, No. 10, p. 966, Pl. 4, fig. 122.

Form obliquely ovate, beak is drawn backward, point of the beak slightly inclined forward according to the growth of the shell, no teeth evident along the hingement, ligament external, obscure narrow umbonal region. Differs from Inoceramus in that a sinus appears beneath the beak and a ligamentary groove appears to replace the row of ligamentary pits in Inoceramus.

Hypotype locality - Drystone Creek, Alberta.

Hypotype - Geol. Mus. Coll., University of Alberta.

Remarks

All the characteristics preserved in these specimens indicate a close relationship to the Aucella mosquensis group. However, since only one valve and one mould were available for study, the author feels that more specimens are required before the identification can be considered certain beyond any question or doubt.

Order EULAMELLIBRANCHIA

Super Family UNIONIACEA

Genus ANODONTA

Anadonta (?) sp.

Plate 13, Fig. 2.

Slightly inequilateral, round triangular, concentrically sculptured exterior, beak subcentrally located, dentition obscure.

Hypotype locality - Villeneuve Creek, 300 feet below the Cadomin conglomerate.

Hypotype - Geol. Mus. Coll., University of Alberta.

Remarks

These hypotypes are extremely fragile and rather difficult to find since their coloring is dark grey to black, and the rock in which they are set is also a dark grey shale. None of the internal characteristics of the specimens figured in Plate 13 can be easily examined and as a result, the identification is questionable.

CHAPTER FIVE

MECHANICAL ANALYSIS

A mechanical analysis is defined as an analysis of the particle-size distribution of a sediment (Pettijohn, 1949).

Seven sandstone outcrop samples of the Nikanassin formation of type area were mechanically analyzed and the results are plotted as histograms, frequency polygons, and cumulative frequency curves. The samples chosen for analysis are spaced at approximately equal vertical intervals through the formation as it outcrops in the type area near Cadomin.

Since the clay content of most of the sandstone specimens taken appeared to be unusually high, the author felt that pipette analyses would be necessary supplements to the results obtained from the mechanical analyses of the sand size portions.

PROCEDURE

Disaggregation and Sieve Analysis

As the samples for analysis were well lithified, the primary step in their preparation was disaggregation. A buckingboard and muller was used in order to avoid fragmentation of the grains. After preliminary crushing, each sample was examined under a stereo-microscope and any sand aggregates which still remained were isolated and subjected to further disaggregation.

Once the entire sample was satisfactorily granulated, it was passed through a series of U.S. Standard Sieves. Following is a list of the mesh sizes used and the corresponding sieve openings.

U.S. sieve series mesh	Corresponding sieve openings (mm)
60	0.250
80	0.177
120	0.125
170	0.088
230	0.062

Each sample was sieved for 10 minutes in a Tyler "Ro-tap" sieve shaker.

The fractions of the sample retained on each sieve screen were weighed and these figures recorded. From these basic data, calculations of weight percent and cumulative weight percent were made and then plotted in the form of histograms (see Figs. 3 to 9 inclusive), frequency polygons (see Figs. 3 to 9 inclusive), and cumulative curves (see Figs. 10 to 16 inclusive) respectively.

The pan fraction obtained from each sieving was saved for pipette analysis.

Pipette Analysis

The pipette method of mechanical analysis is based on relative settling velocities and is used to study the size distributions of particles finer than 1/16 mm.

The method used was that described by Twenhofel and Tyler (1941, p.54). The analysis was carried down to a particle diameter of 1/1024 mm.

HISTOGRAMS AND FREQUENCY POLYGONS

For the histograms (see Figs. 3 to 9 inclusive) the Wentworth Grade scale is plotted along the x-axis and weight percentages along the y-axis. It should be noted that since the silt and clay (that is, particles smaller than 0.062 mm.) grade intervals determined were twice those of the sand fractions, this part of the histogram is less detailed than for the coarse fraction.

Frequency polygons are prepared by plotting the frequency corresponding to a given grade size at a point midway between the grade limits.

CUMULATIVE FREQUENCY CURVES

The cumulative frequency curve is calculated from the same data as the histogram. Particle diameter is plotted along the x-axis and the weight percentage frequencies along the y-axis of semi-logarithmic paper.

Seven cumulative frequency curves were drawn and are figured (see Figs. 10 to 16 inclusive). The values of the median (50%) and the first and third quartiles (75% and 25% respectively) are indicated directly on each cumulative curve.

In Table 3, principle size distribution parameters are given. (The modes were obtained from the frequency polygon.)

Skewness (symmetry) was calculated with the formula:

$$\text{Skewness (Sk)} = \frac{Q_1 Q_3}{(\text{Median})^2}$$

where Q_1 = first quartile (75%)

Q_3 = third quartile (25%)

Median = that diameter greater than 50% of the diameters by weight in the distribution.

Skewness is a measure of the degree of departure of the arithmetic mean of the quartiles from the median. The values of (Sk) may be interpreted as follows:

(Sk) less than 1 -- fine admixtures exceed coarse

(Sk) equals 1 -- fine and coarse admixtures approximately equal

(Sk) greater than 1 -- coarse admixtures exceed fine

The coefficient of sorting was derived for each sample by using the following formula:

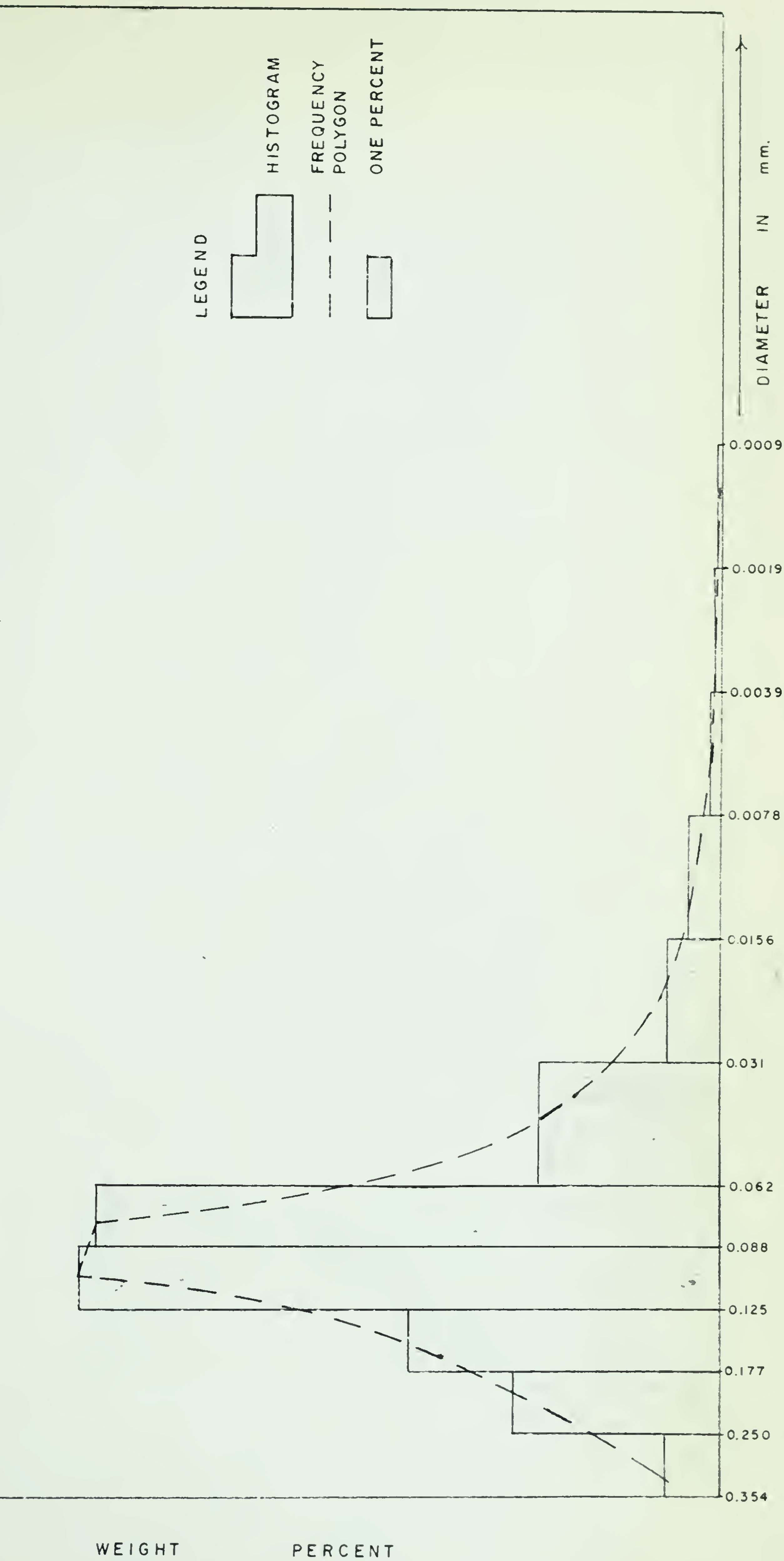
$$\text{Coefficient of sorting (So)} = \frac{Q_3}{Q_1}$$

The coefficient of sorting essentially measures the spread of a cumulative curve. Trask (Pettijohn, 1957) placed the following interpretations on the values of (So):

(So) less than 2.5 -- well sorted

(So) approximately 3.0 -- normally sorted

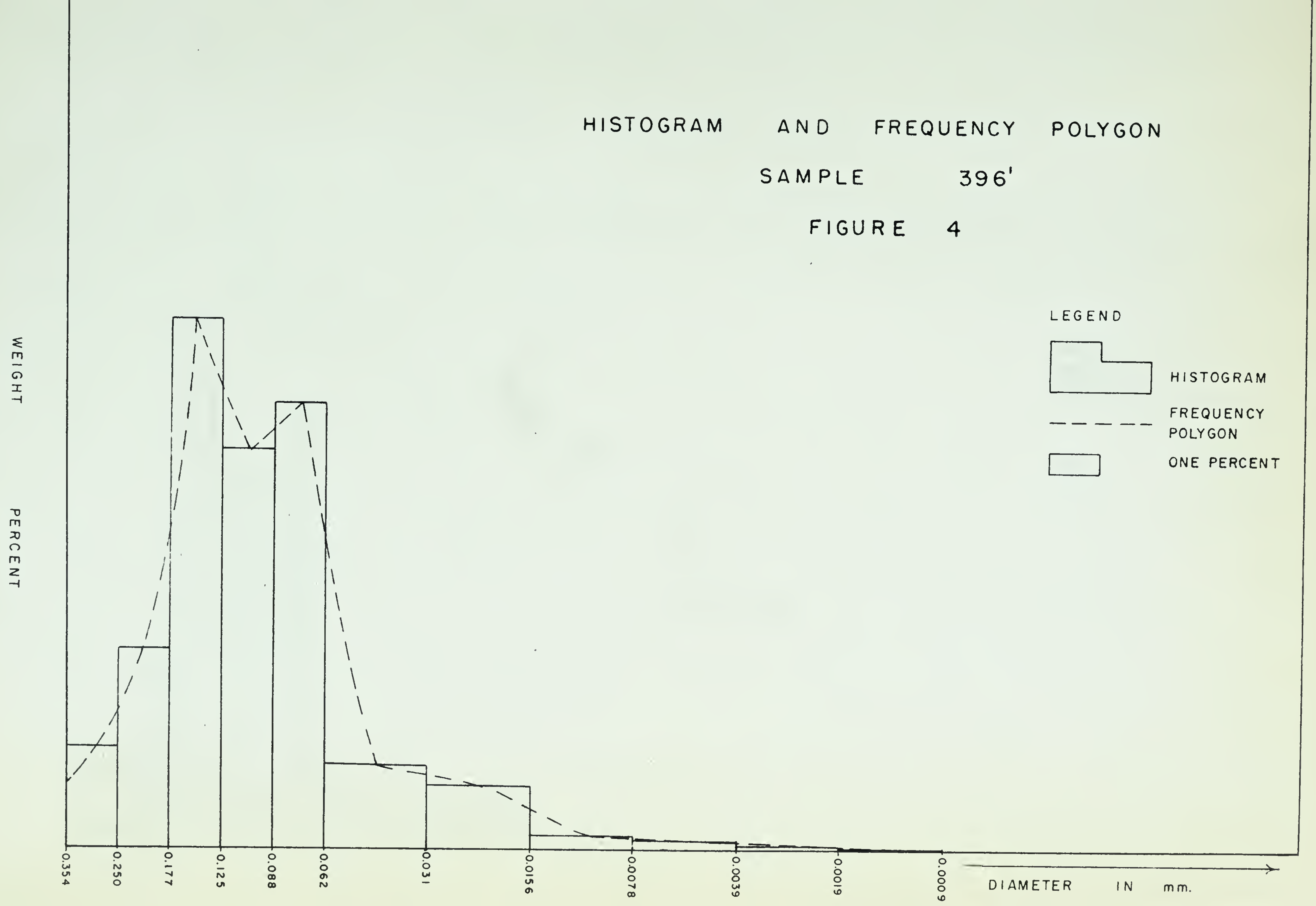
(So) greater than 4.5 -- poorly sorted

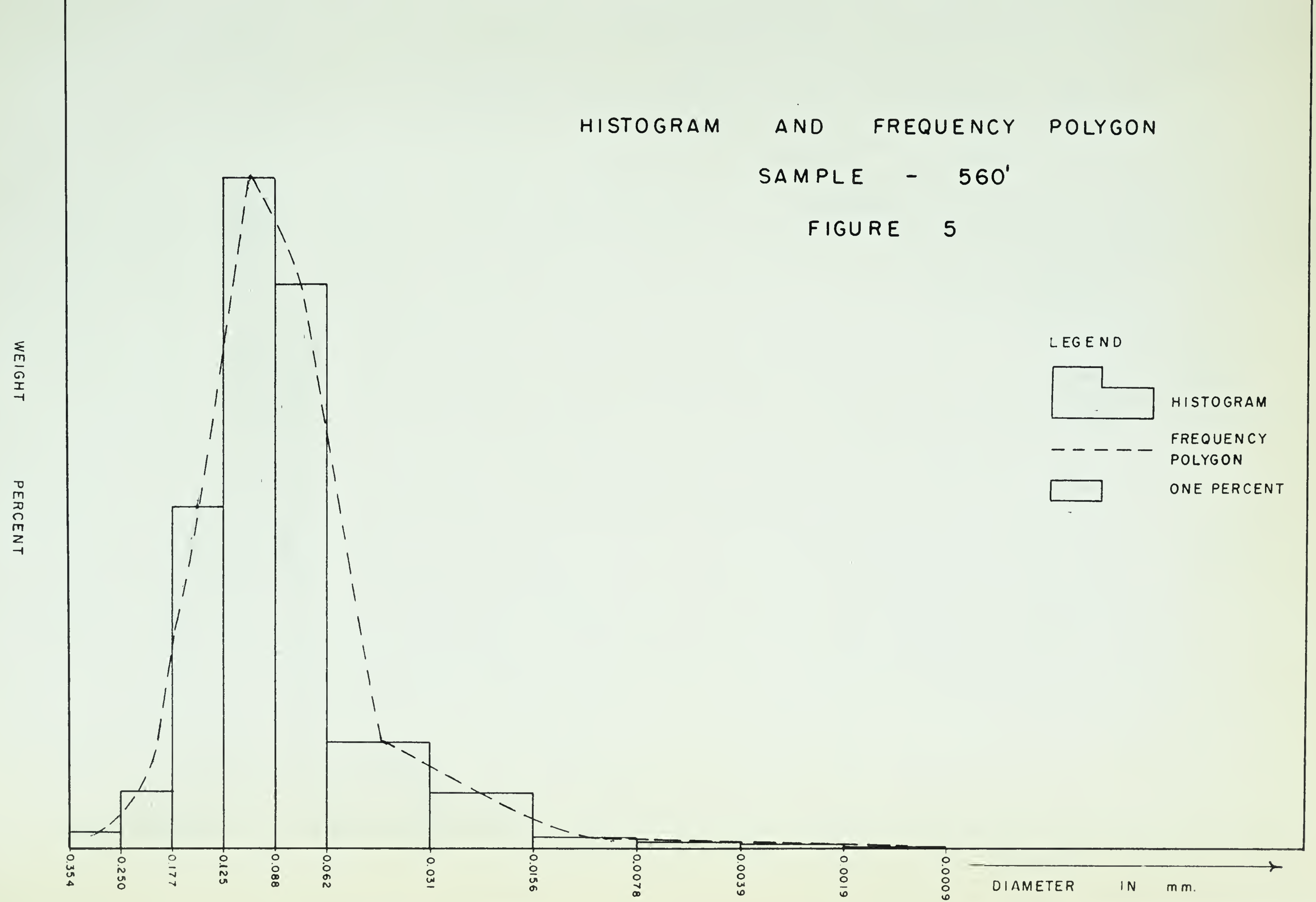


HISTOGRAM AND FREQUENCY POLYGON

SAMPLE - 50'

FIGURE 3

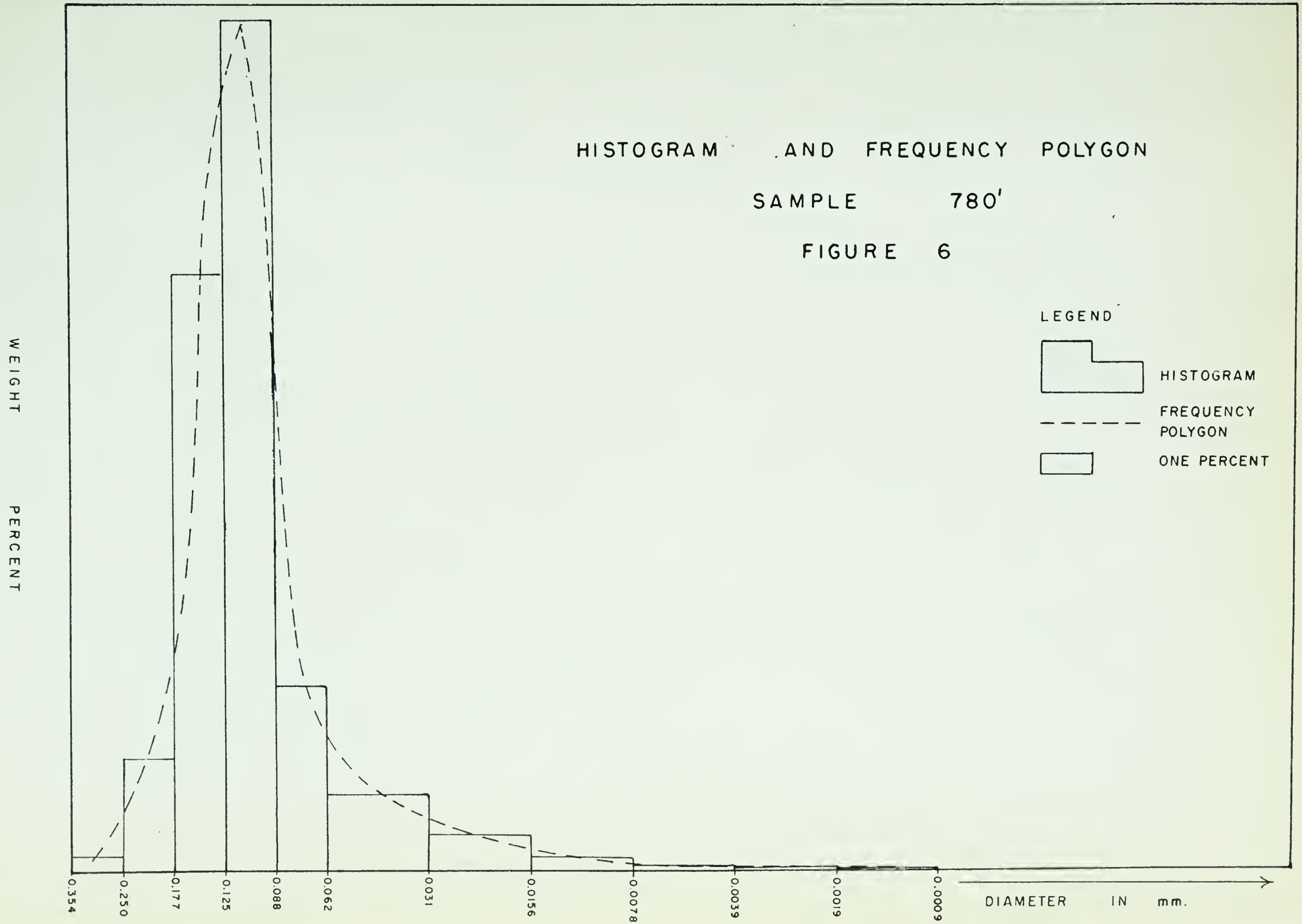

HISTOGRAM AND FREQUENCY POLYGON
SAMPLE 396'
FIGURE 4
LEGEND
HISTOGRAM
FREQUENCY POLYGON
ONE PERCENT
WEIGHT PERCENT
0.354
0.250
0.177
0.125
0.088
0.062
0.031
0.0156
0.0078
0.0039
0.0019
0.0009
DIAMETER IN mm.



HISTOGRAM AND FREQUENCY POLYGON

SAMPLE - 560'

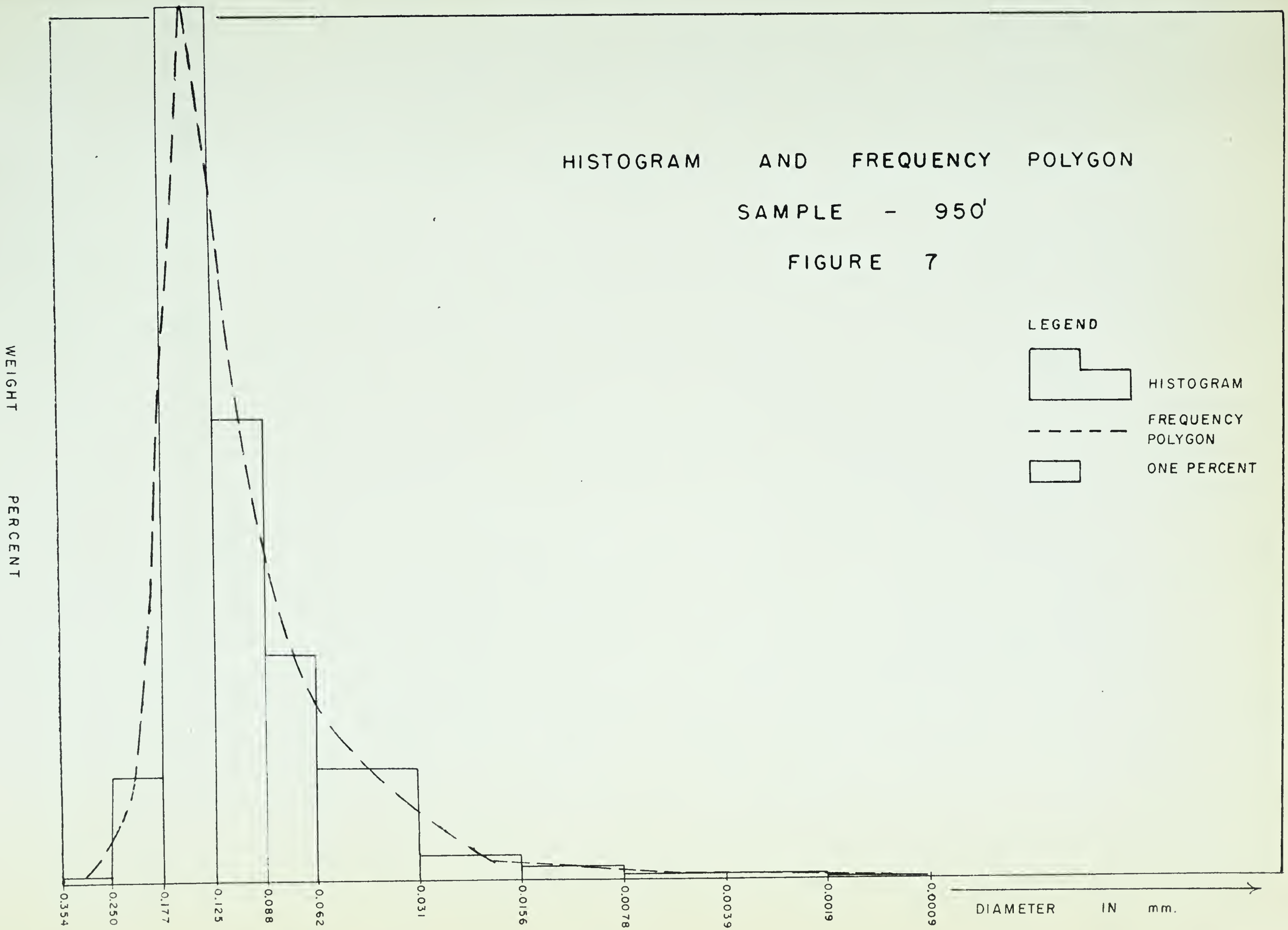
FIGURE 5



HISTOGRAM AND FREQUENCY POLYGON

SAMPLE 780'

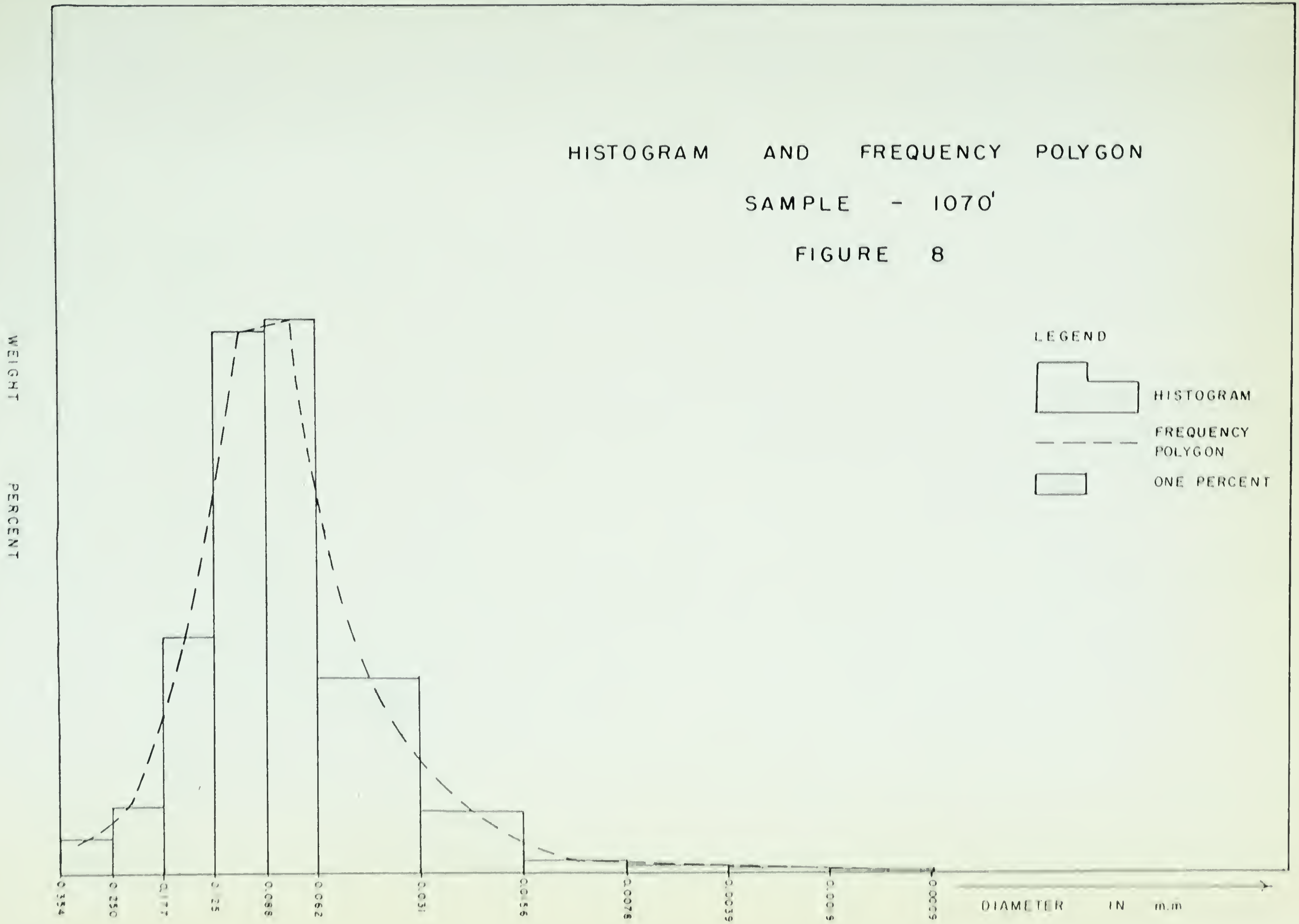
FIGURE 6



HISTOGRAM AND FREQUENCY POLYGON

SAMPLE - 950'

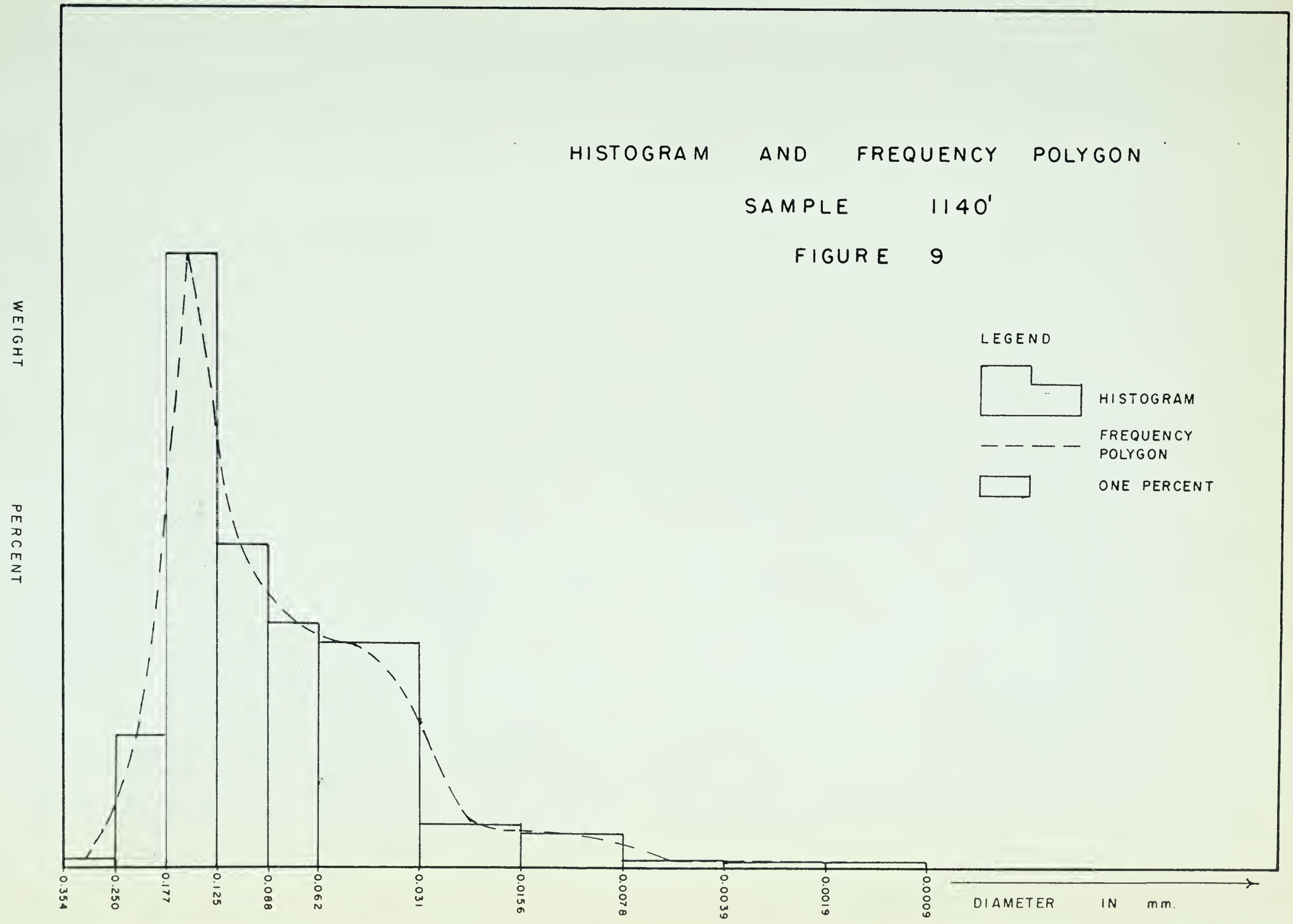
FIGURE 7



HISTOGRAM AND FREQUENCY POLYGON

SAMPLE - 1070'

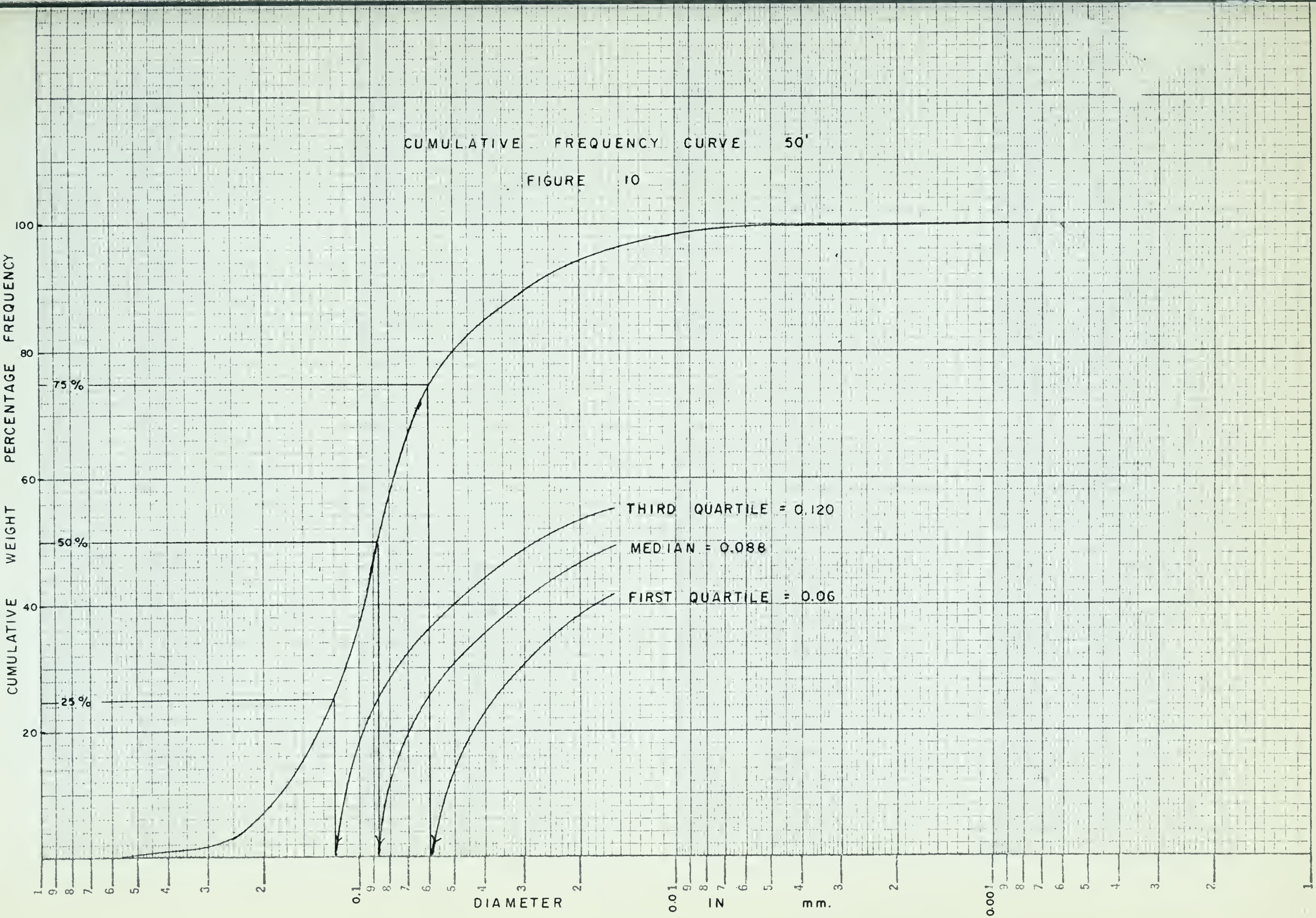
FIGURE 8

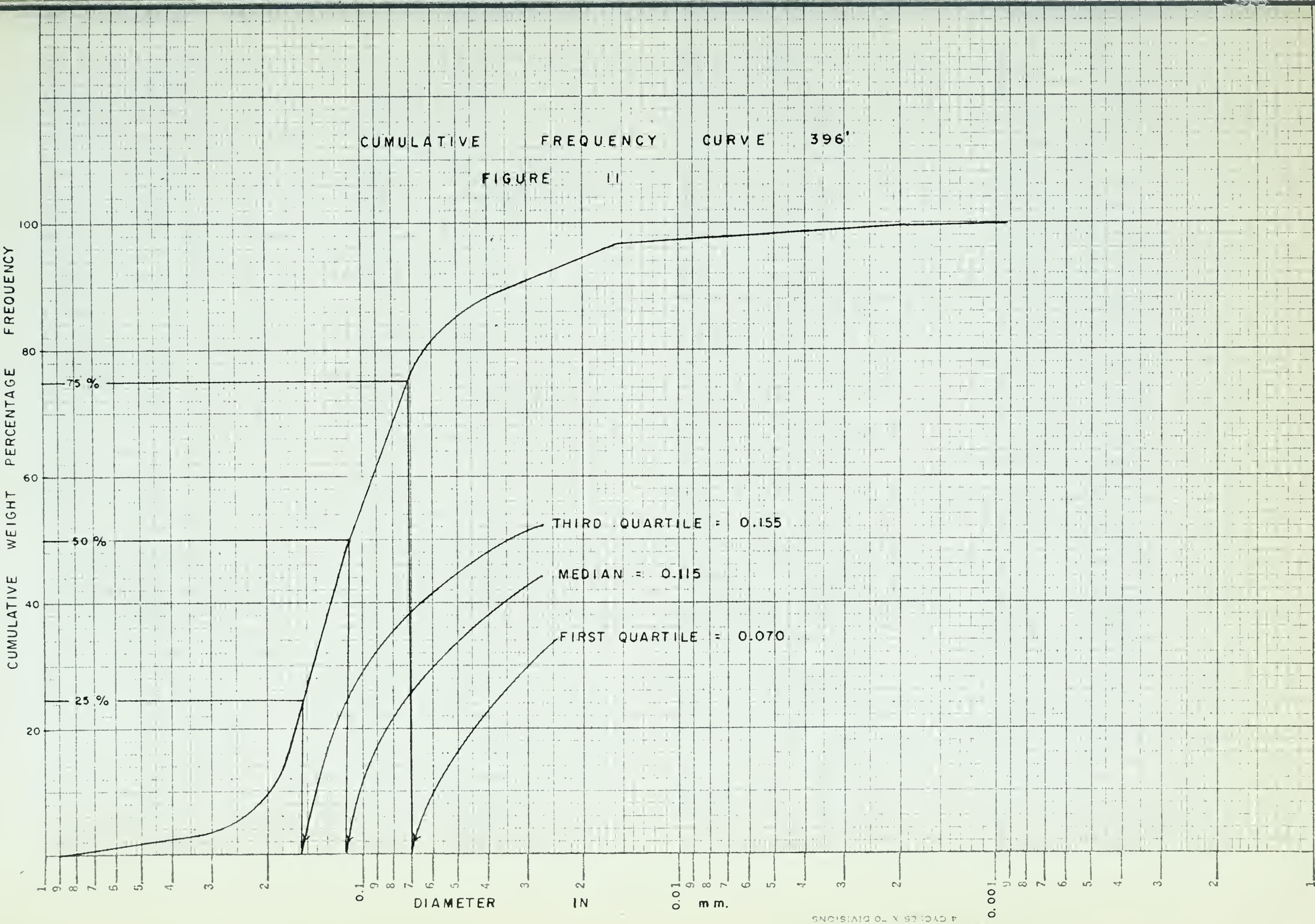


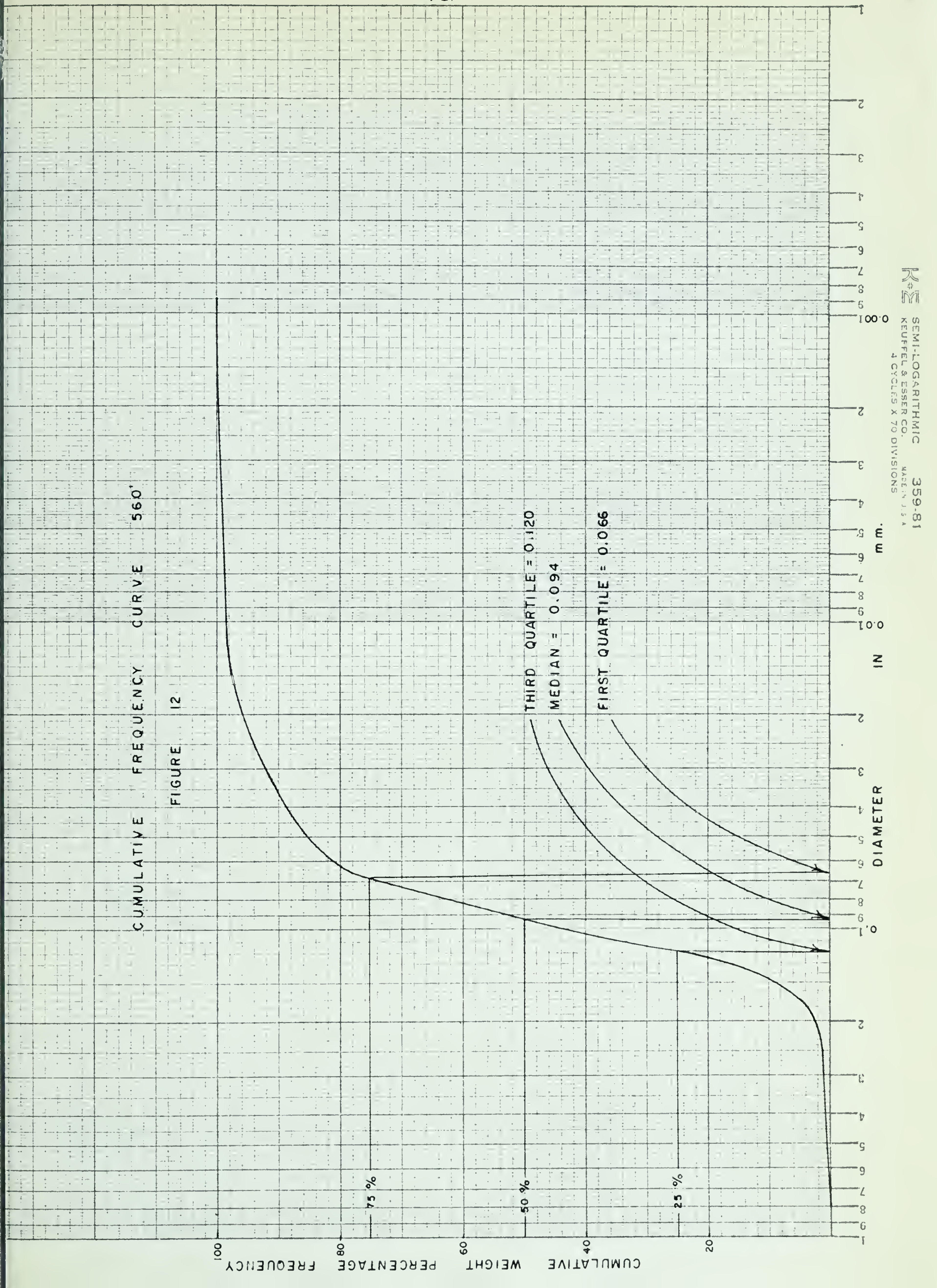
HISTOGRAM AND FREQUENCY POLYGON

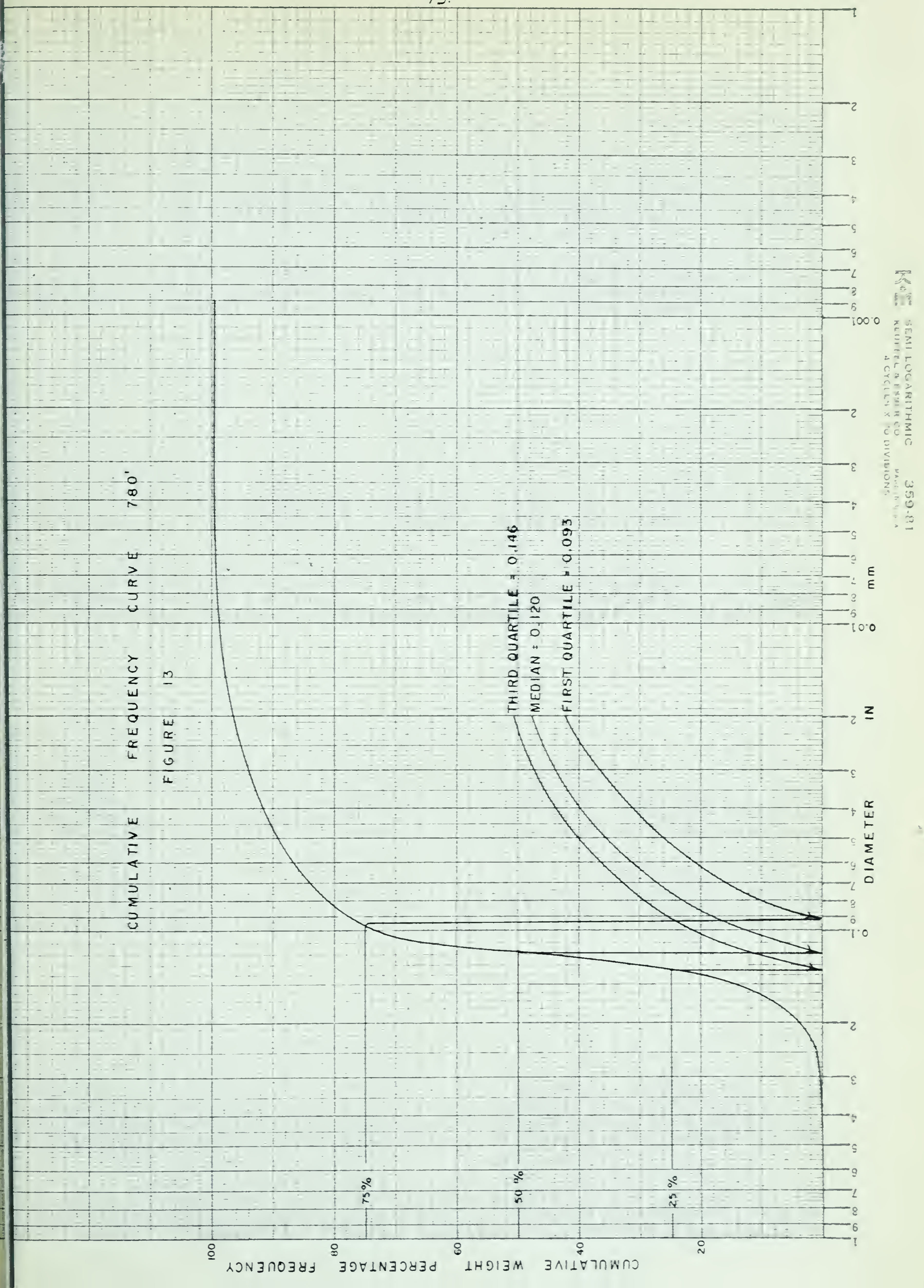
SAMPLE 1140'

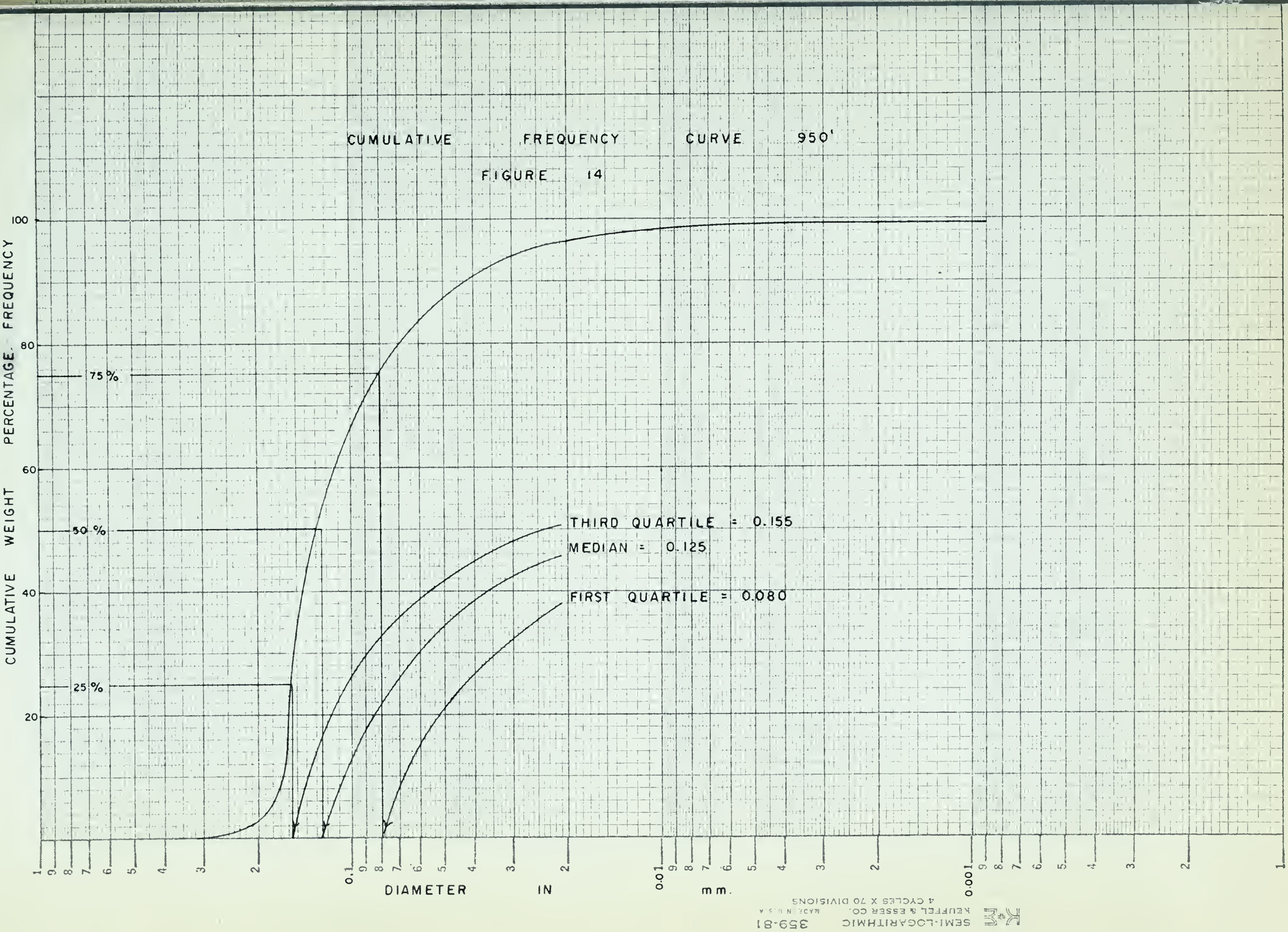
FIGURE 9

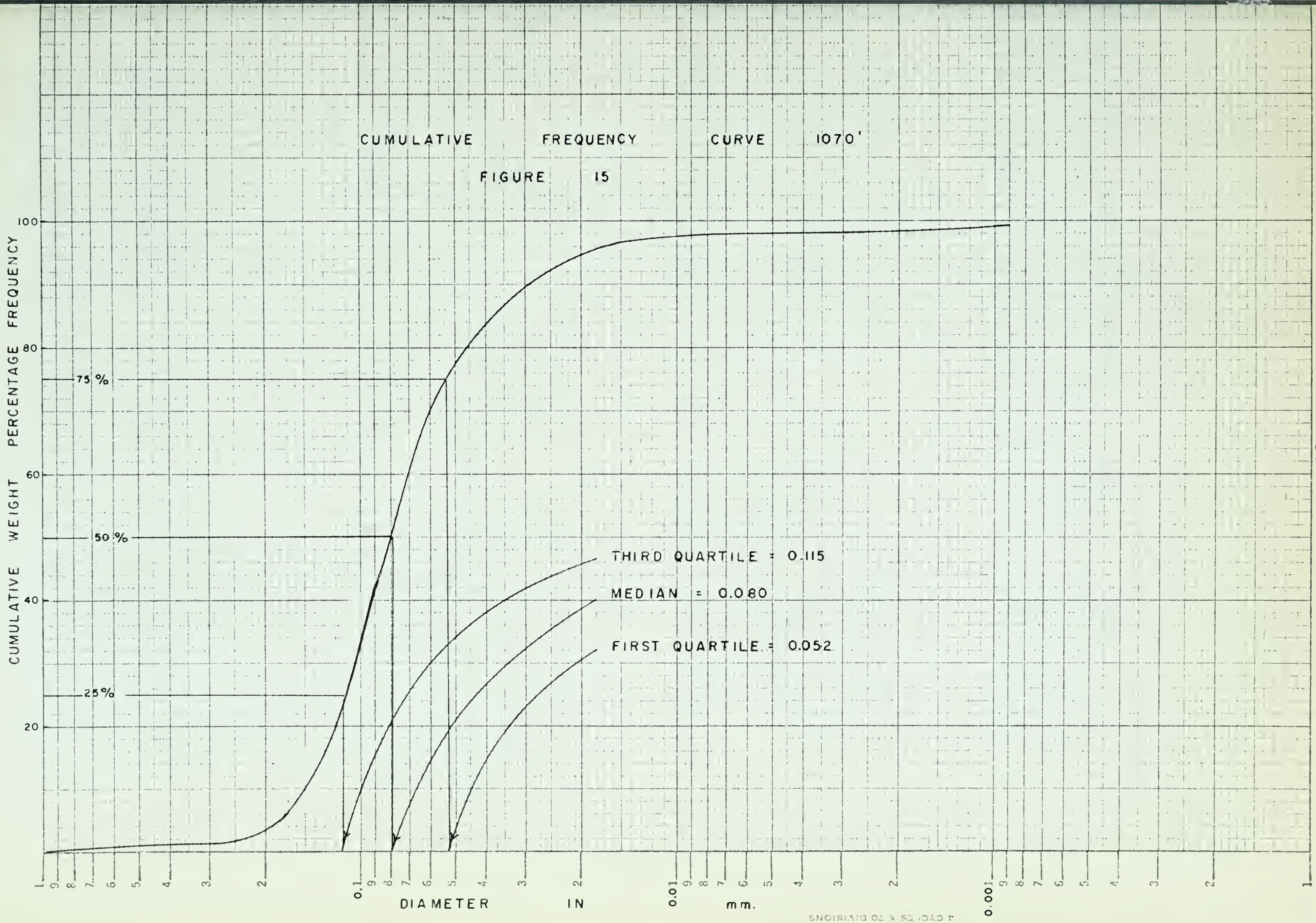

CUMULATIVE FREQUENCY CURVE 50'
FIGURE 10
CUMULATIVE WEIGHT PERCENTAGE FREQUENCY
100
80
60
40
20
75%
50%
25%
THIRD QUARTILE = 0.120
MEDIAN = 0.088
FIRST QUARTILE = 0.06
DIAMETER IN mm.
0.1
0.01
0.001


CUMULATIVE FREQUENCY CURVE 396'
FIGURE 11
CUMULATIVE WEIGHT PERCENTAGE FREQUENCY
100
80
60
40
20
75 %
50 %
25 %
THIRD QUARTILE = 0.155
MEDIAN = 0.115
FIRST QUARTILE = 0.070
0.1
0.01
0.001
DIAMETER IN mm.


CUMULATIVE FREQUENCY CURVE 560'
FIGURE 12
THIRD QUARTILE = 0.120
MEDIAN = 0.094
FIRST QUARTILE = 0.066
75 %
50 %
25 %
100
80
60
40
20
CUMULATIVE WEIGHT PERCENTAGE FREQUENCY
0.001
0.01
0.1
DIAMETER IN mm.
SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS


CUMULATIVE FREQUENCY CURVE 780'
FIGURE 13
THIRD QUARTILE = 0.146
MEDIAN = 0.120
FIRST QUARTILE = 0.093
75%
50 %
25 %
100
80
60
40
20
CUMULATIVE WEIGHT PERCENTAGE FREQUENCY
DIAMETER IN mm
0.001
0.01
0.1
1
SEMI LOGARITHMIC 359-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS


CUMULATIVE FREQUENCY CURVE 950'
FIGURE 14
THIRD QUARTILE = 0.155
MEDIAN = 0.125
FIRST QUARTILE = 0.080
75 %
50 %
25 %
100
80
60
40
20
CUMULATIVE WEIGHT PERCENTAGE. FREQUENCY
DIAMETER IN mm.
0.1
0.01
0.001
SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS


CUMULATIVE FREQUENCY CURVE 1070'
FIGURE 15
CUMULATIVE WEIGHT PERCENTAGE FREQUENCY
100
80
60
40
20
75 %
50 %
25 %
THIRD QUARTILE = 0.115
MEDIAN = 0.080
FIRST QUARTILE = 0.052
1 9 8 7 6 5 4 3 2 0.1 9 8 7 6 5 4 3 2 0.01 9 8 7 6 5 4 3 2 0.001 9 8 7 6 5 4 3 2 1
DIAMETER IN mm.

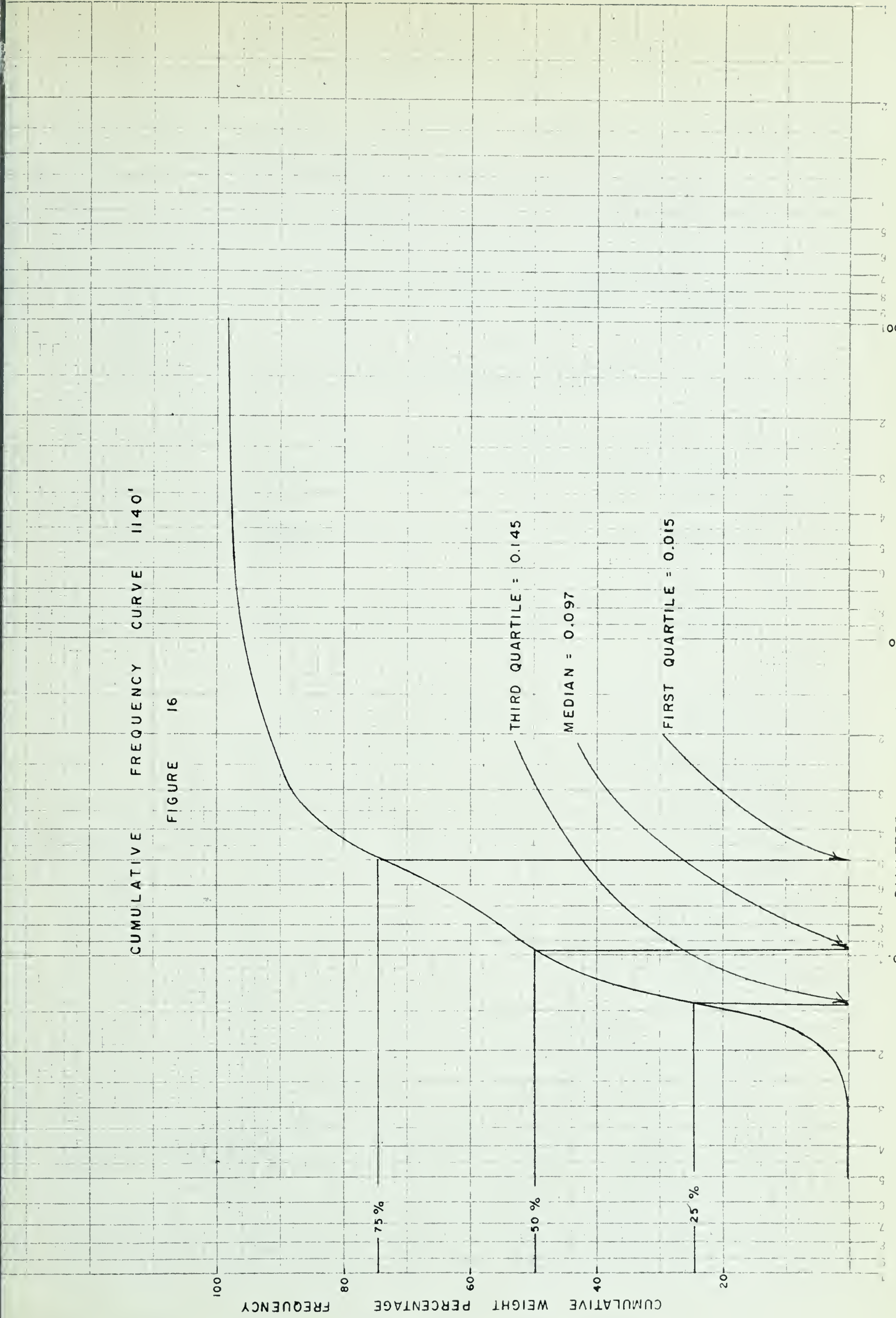

CUMULATIVE FREQUENCY CURVE 1140'
FIGURE 16
THIRD QUARTILE = 0.145
MEDIAN = 0.097
FIRST QUARTILE = 0.015
75 %
50 %
25 %
100
80
60
40
20
CUMULATIVE WEIGHT PERCENTAGE FREQUENCY
DIAMETER IN mm.
0.001
0.01
0.1

TABLE 3

DATA OBTAINED FROM THE MECHANICAL ANALYSES OF THE NIKANASSIN FORMATION OF THE TYPE AREA

FOOTAGE (FT.)	COEFFICIENT OF SORTING	SKEWNESS	MEDIAN (MM)	MODE(S) (MM)	TYPE OF DISTRIBUTION
50'	1·67	0·82	·088	0.105	UNIMODAL
396'	1·41	0·92	0·115	0·149	UNIMODAL
560'	1·34	0·59	0·116	0·105	UNIMODAL
780'	1·27	0·94	0·120	0·105	UNIMODAL
950'	1·40	0 79	0·125	0·149	UNIMODAL
1070'	1·42	1·00	0·080	0·074	UNIMODAL
1140'	3·1	0·15	0·120	0·149	UNIMODAL

INTERPRETATION

Histograms and Frequency Polygons

All of the histograms, with one possible exception, show these samples to have a unimodal size distribution. The one exception may exist at 396' where the histogram appears to suggest very slight bi-modality.

Diameters of 0.105 mm. and 0.149 mm. are the dominant modes in the majority of cases. Thus, it appears as though sandstones of the Nikanassin formation are predominantly very fine to fine grained.

Cumulative Curves

The cumulative curves all display the smooth "S" character of the normal unimodal curve

The coefficients of sorting range from 1.27 to 3.1. Applying Trask's interpretations (see p. 68) to these sorting values leads one to conclude that six of the seven sands are well sorted, while the remaining one falls into the category of normally sorted sediments.

Similarly, skewness figures indicate that six of the seven sands are skewed such that fine admixtures exceed the coarse, while the remnant sandstone contains approximately equal fine and coarse admixtures.

CHAPTER SIX

HEAVY ACCESSORY MINERALS

General Statement

Heavy minerals of the Nikanassin formation of type section were extracted from eighteen samples critically spread over the approximate 1300 feet of beds. Ten of the eighteen samples used were taken from the section measured at Mackenzie Creek, while the remaining eight are from the "Lower" Nikanassin as measured at Prospect Creek and the "Middle" and "Upper" Nikanassin beds exposed along the Canadian National Railway track at Cadomin.

The specimens for heavy mineral analysis were chosen so that one sample would represent each 100 feet of as complete a type section as possible. In a number of places, however, variation in lithology was so great that a 100-foot interval was of necessity represented by two or more specimens.

The samples were ground manually on a buckingboard until they passed through a 60 mesh sieve. The grounds were then sieved and the -80+170 fraction of each sample was isolated for heavy mineral separation.

Separation

In separating the heavy accessory minerals from the essential light minerals, the following method was employed.

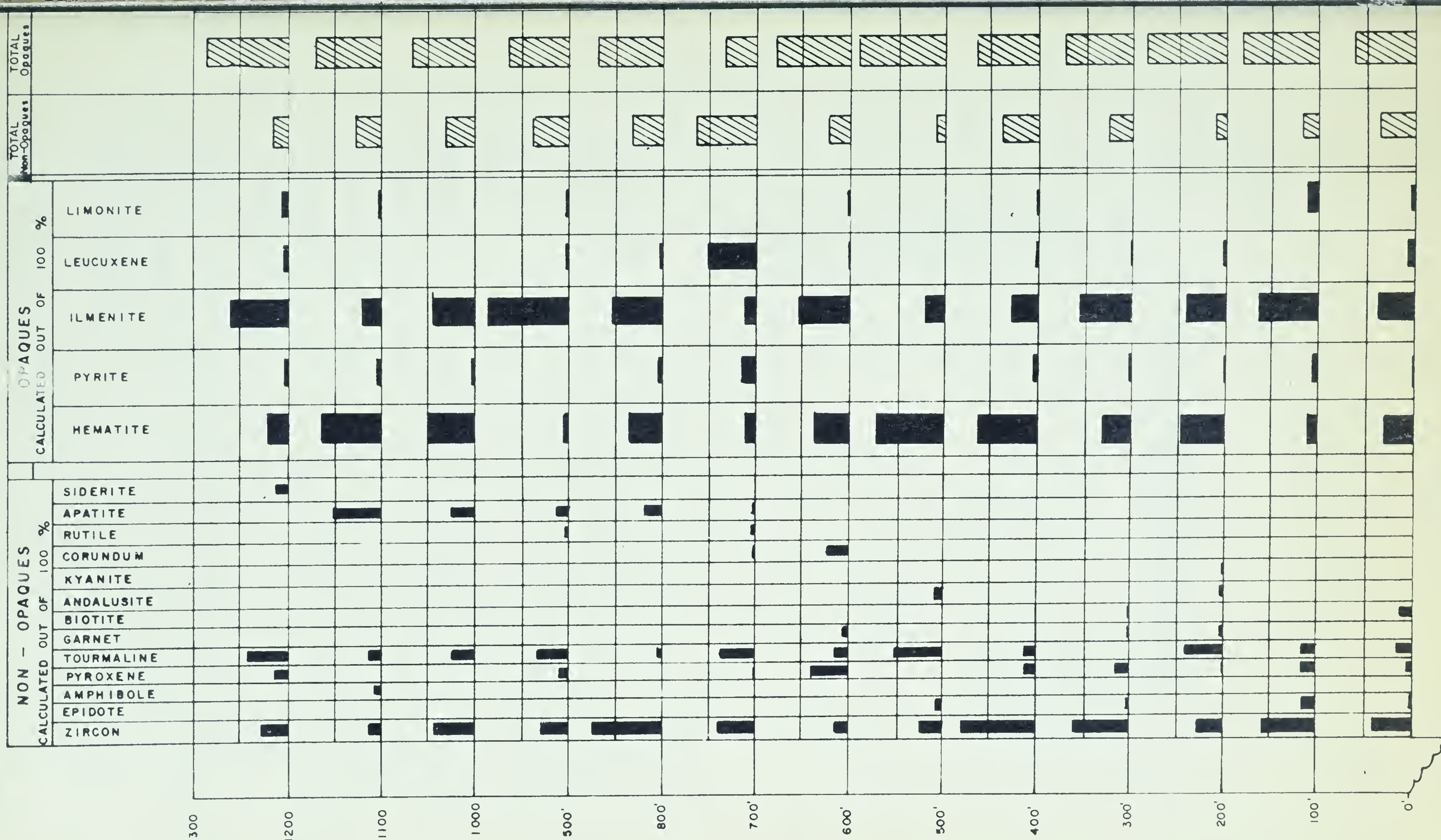
The apparatus for each separation consisted of separatory funnel (with stopcock), two clamps, a stand, one conical funnel, and a number of 250 ml beakers. The separatory funnel was set up over the conical

funnel lined with No. 1 filter paper, and a beaker placed below. The separatory funnel was partly filled with tetrabromethane ($CHBr_2$ $CHBr_2$) - (specific gravity 2.950/20° C.) - and this heavy liquid was agitated until all of the -80+170 sieve fraction added was sufficiently well mixed to allow complete dispersal of the mineral grains. The system was allowed to stand until the primary rain of heavy accessory minerals settled out. Then the mineral float in the separatory funnel was again agitated in order to ensure that any additional heavy minerals trapped in the float would also settle out. The heavy mineral concentration was then passed onto the filter paper of the conical funnel and the accompanying tetra-bromethane was drained off. The light mineral fraction left floating in the tetrabromethane of the separatory funnel was drained off in an identical manner. Both the light and heavy mineral fractions were washed with acetone and left to dry.

Preliminary to mounting of the heavy accessory minerals in Aroclor (n=1.66), a strong hand magnet was carefully passed over each sample in order to remove magnetite and any contaminating iron or steel particles which might have been present.

The eighteen Aroclor mounts were then examined and it was noted that each slide contained grains coated with ferruginous material to the extent of about 30% - 35%. Approximately 80% of these filmed grains are quartz, and the remaining 20% are calcite and rock fragments.

For each slide, all the non-opaque and opaque minerals were recorded. From these figures a graphic chart (see Table 4) was prepared which compares percentage-wise the abundances.



TABULATIONS OF THE HEAVY
ACCESSORY MINERAL DATA OF THE
NIKANASSIN FORMATION
OF
TYPE AREA

TABLE 4

In addition, photomicrographs of some of the heavy minerals present in the Nikanassin formation of type section are shown in Plates 10, 11, and 12.

List of Heavy Accessory Minerals

Non-Opaques	Opaques
Andalusite	Hematite
Apatite	Ilmenite
Augite	Leucoxene
Biotite	Limonite
Corundum	Pyrite
Cummingtonite	
Diopside	
Epidote	
Garnet	
Hornblende	
Kyanite	
Pigeonite	
Rutile	
Siderite	
Tourmaline	
Zircon	

Description of Non-Opaque Heavy Minerals

Andalusite - Colorless; subgranular or subrounded stubby prismatic grains; pleochroic from colorless to green. Source is contact metamorphic rock.

Apatite - Colorless and seldom coated with ferruginous material as are similar quartz grains present; stubby subrounded to subangular prismatic grains are most common; some grains contain very minute dark-grey and black spicular-type inclusions. Original sources are metamorphosed limestones and igneous rocks.

Augite - Light-green to colorless; fragments are angular to subangular prisms; nonpleochroic. Sources are igneous rocks of intermediate and basic character.

Biotite - Dark-blackish-brown; angular flakes; nonpleochroic. Sources are igneous and metamorphic rocks.

Corundum - Colorless; grains irregular and angular; tiny black acicular inclusions in some grains; majority of grains yield excellent uniaxial negative figures. Sources are igneous rocks or contact metamorphosed limestones.

Cummingtonite - Colorless; subangular prismatic; surface altered to a light green color in longitudinal strips across one grain; some dark elongate liquid inclusions present; extinction is undulatory. Sources are hornfels.

Diopside - Colorless; angular and subangular prismatic grains; surfaces altered slightly in a reticulate-type pattern to pale-greenish chlorite. Sources are basic igneous rocks, gneisses, schists, and contact metamorphic rocks.

Epidote - Light-green and greenish-yellow; grains are largely subangular to angular and irregular; samples near the top of the section are particularly "hackly" in appearance. The epidote may have been derived either from crystalline metamorphosed impure limestones or from altered igneous rocks originally rich in the ferro-magnesian minerals.

Garnet - Colorless to light-pinkish-grey; irregular angular grains; subconchoidal fracture very pronounced in some grains. Sources of garnet are metamorphosed rocks and some igneous rocks and pegmatites.

Hornblende - Light-green; grains are prismatic, elongate, and exhibit ragged terminations; pleochroic light to dark green; some grains show alteration to dark-greyish-green and dark-grey chloritic material along the rims. Sources are metamorphic as well as acid and intermediate igneous rocks.

Kyanite - Colorless; subrounded to subangular short prismatic grains. Sources are mica schists and gneissic rocks.

Rutile - Reddish-brown; subrounded to subangular acicular and tetrahedral grains; inclined striae or markings are visible on the majority of the grains. Sources of rutile are crystalline metamorphic and acid igneous rocks.

Siderite - Dark-brown to reddish-brown; rounded or subrounded grains; a minority of grains show a slight trace of faint radiate structure along the rim. Considered to be authigenic or intraformational.

Tourmaline - Like zircon, tourmaline grains are present in all but one interval; colors most common are shades of olive green and olive brown; other less abundant colors present are light green and light yellow; the major portion of the tourmaline assemblage consists of grains which are subrounded stubby squares and prisms; most of the grains are extremely well rounded; pleochroism is most striking in the olive green varieties.

Krynine (1946) listed five main sources of sedimentary tourmaline:

(1) Granitic tourmaline; dark-brown, green or pink (with a greenish cast); frequently full of bubbles and inclusions.

(2) Pegmatitic tourmaline; blue, with pleochroism in shades of mauve and lavender; inclusions are rare.

(3) Tourmaline from metamorphic rocks; in pegmatized sandstone, pale to deep brown, poor in inclusions; in slates, phyllites, and quartzose mica-schists, colorless to very pale brown, frequently full of black carbonaceous inclusions if the injected phyllite was originally a dark or black shale.

(4) Sedimentary authigenic tourmaline, occurring as colorless overgrowths on detrital grains; show polar development at one end only of the c-axis; overgrowths may develop on brown, blue, green, yellow, or black cores.

(5) Reworked tourmaline from older sediments; any of the primary sources that has been reworked.

The tourmalines present in the Nikanassin formation are reworked (Krynine's type 5). They suggest, in addition, that the primary sources represented were predominantly granitic and metamorphic rocks.

Zircon - Zircon is the most abundant non-opaque heavy mineral present and was observed in all slides; colorless variety very common and generally euhedral to subhedral and angular; other grains are dark brownish grey, subhedral, irregular and subangular to subrounded; liquid inclusions of various sizes and shapes are present chiefly on the euhedral specimens; in one or two slides raggedy edged overgrowths covered original grains of zircon; in cases where there are both rounded and highly angular edges on a single grain, the specimen has undoubtedly been fractured recently. Zircon is ultimately probably derived from acid and intermediate igneous rocks. Perhaps the euhedral and subhedral grains represent first cycle addition of zircon to the Nikanassin environment, as compared with the older, well rounded grains which are obviously re-worked from sedimentary sources.

Description of Opaque Heavy Minerals

Hematite - Rounded to subrounded grains of reddish-brown color by reflected light. Not easily confused with any of the other opaque minerals. Sources are igneous and metamorphic rocks.

Ilmenite - Grains are irregular in shape; under reflected light the grains have a steel- to purplish-grey sheen; distinguished from titaniferous magnetite by its common association with leucoxene. Sources are mainly basic and utrabasic rocks.

Leucoxene - Grains are irregular to subrounded and appear white or yellowish white in reflected light. Most often derived from ilmenite.

Limonite - Occurs as irregular grains which are brownish-orange in reflected light. Originates mainly as an alteration product of other iron-bearing minerals.

Pyrite - Occurs as irregular aggregates of various isometric crystal expressions; bright brass yellow by reflected light. Mainly authigenic in origin.

Magnetite - Present in all samples and was removed along with contaminating iron and steel particles.

In conclusion it should be emphasized that the opaque heavy mineral portion of each slide appears to greatly exceed the non-opaque portion because of the great concentration of hematite- and limonite-stained quartz, calcite, and rock fragments present. However, these ferruginously-stained grains were not counted with the opaques.

CHAPTER SEVEN

PETROGRAPHY OF THE SANDSTONES

Introduction

Thin sections were prepared from the outcrop samples of the Nikanassin formation from the four sections measured in this study. Eighty-two thin sections were prepared; seventy-six by Mr. Fred Roberts, Petrographic Thin Section Service, Alhambra, California, and six by the technicians of the Alberta Research Council. Only thirteen of these thin section samples required impregnation during preparation and all eighty-two slides are of excellent quality. Samples were selected in such a manner that there was at least one sample from every one hundred feet of section, and also, a specimen for each change in lithology. Following is the resultant thin section distribution by outcrop sections:

Cadomin Railroad-1 .... 32 thin sections

Mountain Park Railroad-1 ...... 18 thin sections

Mackenzie Creek-1 .... 28 thin sections

Prospect Creek-1 .... 4 thin sections

The locations of the thin sections prepared are found in Appendix D.

It was not deemed pertinent nor practical to present detailed accounts of all the rock sections. Instead, a general description of the rocks is given below, and detailed descriptions of seventeen of the more representative sections are presented in Appendix A.

General Description of Thin Sections

The grain size of the rocks studied in thin section ranged from 0.06 mm. to 0.50 mm. (that is, from silt to a medium-grained sand). The majority of the samples were in the 0.1 to 0.2 mm. range (that is, from very fine to fine sand). The grain size chart used was that given by Twenhofel and Tyler (1941, p. 48).

The samples appeared to be generally well sorted; however, in a small number of cases, the sorting was poor or poor to fair. These petrographic results coincide rather well with those obtained from the mechanical analyses which showed the rock to be predominantly well sorted.

Individual grains were found to vary in roundness from angular to well rounded; however, the majority of the grains fall into the angular to subrounded classification. Generally, there was no marked differentiation in the roundness of grains of various composition in any one slide. However, in a few slides it was possible to make a threefold compositional-roundness distinction: rounded rock fragments, subrounded quartz, and subangular to angular quartz and feldspar.

Porosity in all samples is low. In nearly all slides, the grains are closely packed and either the cement or matrix has reduced pore space to less than 3 per cent.

Although the kind of cementation is variable, silica overgrowths on quartz is the most common cementing agent. Other materials acting as cements are calcite and ferruginous (limonite after pyrite ?) material.

There are three main constituents in the sandstones of the Nikanassin formation, and two of these are somewhat more prominent than the third.

Quartz and siliceous rock fragments are almost always major components, while argillaceous rock fragments, though nearly always present, are not so abundant. Much of the quartz present exhibits undulatory extinction and secondary overgrowths of silica. These silica overgrowths on the quartz not only give many of the grains sutured contacts, but also tend to increase the angularity of the grains. Generally, the contact between the core and silica overgrowth is marked by finely disseminated ferruginous material. The rock fragments are mainly chert, although some indefinite very fine grained siliceous rock particles are also present. Both varieties of siliceous rock fragments are generally subrounded. The argillaceous rock fragments, which are mainly silty shale and metamorphic fragments, are usually irregular in shape but mostly subrounded to rounded.

The matrix constituents are numerous and widely variable in composition. In nearly all rocks, quartz finer than 0.1 mm., as well as grains of feldspar and rock fragments of this same dimension, are included as matrix constituents. Other materials which are present in some sections are carbonaceous material, pyrite and mixtures of clay (illite), and mica (muscovite).

Feldspar grains are present in all samples and are either plagioclase, exhibiting albite twinning, or exhibit the "gridiron" polysynthetic twinning typical of microcline.

Authigenic pyrite is present in small amounts and is distinguished from the more common opaque carbonaceous material by its brilliant brass yellow coloring under reflected light.

The fine, simple, cross-lamination displayed in a number of thin sections appears to bear no relationship to either the grain orientation

or grain composition of the sample. Its only common association seems to be with very fine, irregular laminae of carbonaceous material.

CHAPTER EIGHT

PROVENANCE AND ENVIRONMENT OF DEPOSITION

General Statement

This study is chiefly a detailed examination within a very local area, and only very limited conclusions concerning the source and environment of the Nikanassin formation can be extrapolated from the results obtained.

Provenance

Examination of the heavy mineral assemblage of the Nikanassin formation of the type area reveals that its sources were igneous, metamorphic, and sedimentary. Pre-existing sediments appear to have been the main source, although some contribution was made from igneous and metamorphic sources as well.

Zircons, which are the most common and abundant heavy accessory mineral, are mostly rounded and have probably been derived from a sedimentary source. The few euhedral grains present may have either a volcanic or granitic ancestry. The complete lack of purple colored zircons suggests the absence of a Pre-Cambrian source area.

Tourmaline, the second most abundant heavy mineral in the Nikanassin formation of the type area, is generally rounded to subrounded. Since tourmaline is highly resistant to both mechanical abrasion and chemical attack, it would appear then that the degree of roundness displayed by the mineral is indicative of second or third cycle reworking. According to Krynine's (1946) color classification, it appears as though the original primary source of the tourmaline was either granitic or metamorphic.

Rounding of apatite and rutile is also pronounced to such a degree that these minerals are undoubtedly products of reworked sediments.

Minerals present in the Nikanassin heavy mineral suite which may have had an igneous source are: magnetite, ilmenite, the pyroxenes, and the amphiboles.

The presence of the slightly rounded minerals andalusite, kyanite, epidote and garnet seem to suggest a primary metamorphic source.

Much of the quartz observed in thin section has undulatory extinction, and thus is also suggestive of an original metamorphic source. However, since most of the rounded extremities of the quartz have been covered by secondary overgrowths of silica, it is difficult to determine the real maturity of these grains.

The majority of the rock fragments in the Nikanassin formation are rounded. In the case of the chert and siliceous rock fragments, this would seem to indicate a rather long, abrasional history, such as might be expected after the reworking of an older sediment.

Although the twinned feldspar content is relatively small, the grains of sodic plagioclase and microcline present are relatively fresh. Thus, since feldspars are readily susceptible to mechanical and chemical destruction it would appear that these moderately fresh grains present had a relatively short erosional and abrasional history, and that they are probably primary products of an igneous terrane. Since none of the thin sections were stained and the feldspars were moderately fresh, untwinned sodic plagioclase, which is a normal metamorphic feldspar, may have been present but overlooked.

Even though much of the pyrite lacks any crystal definition it is

nevertheless considered to be almost totally authigenic.

The tabulated heavy mineral data of the composite type section of the Nikanassin formation indicates that the major portion of those minerals from the lower 500 feet of the section were derived from earlier Jurassic rocks. Above 500 feet the introduction of minerals such as apatite, rutile and corundum, coupled with the first appearances of microcline and some unstrained quartz indicate a significant change in the source area. Recently it has been shown that a portion of the Nikanassin is definitely Upper Jurassic in age; consequently, it is postulated that early Nikanassin sediments were derived mainly from pre-existing sedimentary and metamorphic rocks. Later Nikanassin sediments on the other hand, were probably derived not only from similar rocks but also from newly exposed igneous sources which may have been forerunners of the Nevadian orogeny.

Environment of Deposition

Microfossils, megafossils, and various sedimentary criteria have been used to partially reconstruct the depositional environment of the Nikanassin formation.

The foraminiferal assemblage obtained from the Nikanassin formation is entirely arenaceous and the genera suggest shallow water deposition. The absence of calcareous forms seems to exclude open gulf or pelagic deposition. These facts imply that the Nikanassin sediments were deposited in a shallow bay-like environment.

The presence of the fossil flora in the Nikanassin formation indicates that at least during some intervals, deposition was continental or near shore. Numerous thin beds and lenses of coal suggest a swamp type of

depositional environment. Since the majority of the carbonaceous materials preserved are so fragile and easily destroyed, the coal, fossil flora, and carbon residues are not accumulations of extensively transported organic detritus.

The occurrence of Aucella within the Nikanassin indicates marine conditions. However, since specimens of Aucella from the Nikanassin formation are so few and those collected were from highly arenaceous beds, the marine conditions were intermittent and probably lasted for relatively short periods.

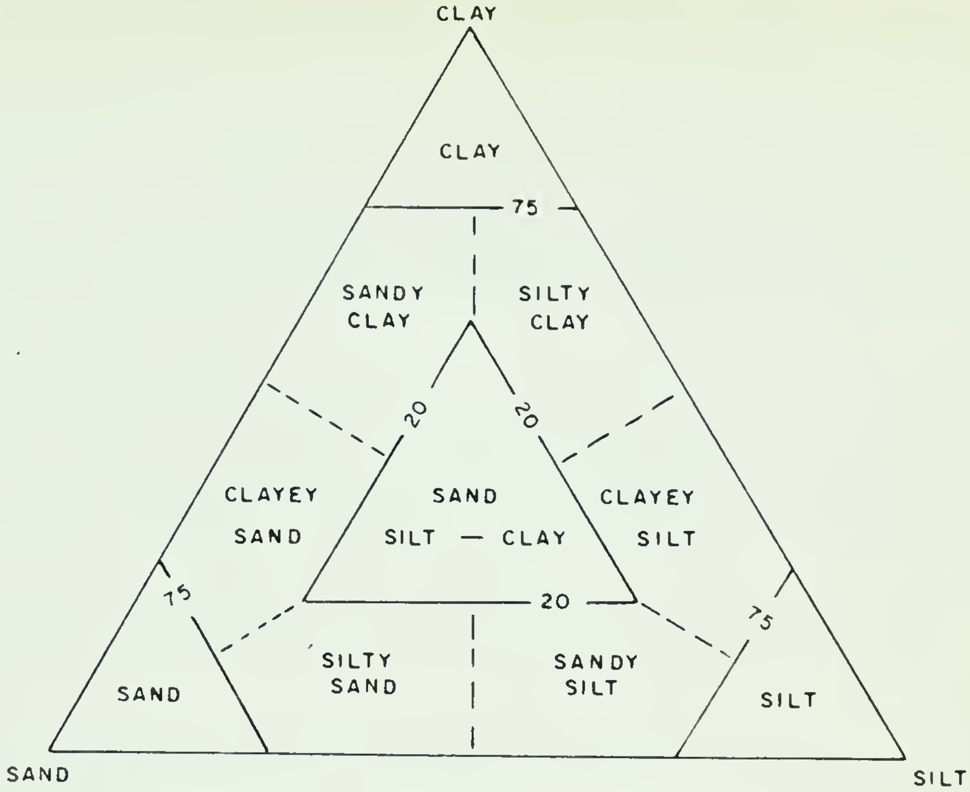
In further interpreting the depositional environment, the sand, silt, and clay proportions of the various mechanically analyzed Nikanassin sandstone were plotted after a system described by Shepard and Moore (1955). This data, which is plotted in Figure 17, seems to suggest that the environment of the Nikanassin formation was similar to Shepard and Moore's shallow bay in the present Gulf Coast area. This sedimentary interpretation, coupled with the support of other sedimentary features such as ripple marks and the well-sorted and rounded nature of the arenaceous particles, indicates conditions of shallow water during deposition.

The presence of pyrite and rare grains of siderite indicate that slightly reducing conditions existed near the depositional interface during certain portions of the depositional history. Krumbein and Garrels (1952) show on chemical grounds that certain mineral suites are the result of rather restricted Eh (oxidation-reduction potential) and pH (acid alkalinity) conditions. Siderite and organic debris, both present in the Nikanassin, are shown as occurring together as major constituents in environments of

pH7 to 7.8 (alkaline but slightly more acid than normal marine) and Eh of 0.0 to 0.15 (neutral to slightly reducing). The writer believes that the siderite and organic matter were probably deposited above the depositional interface, while the pyrite originated below this same boundary.

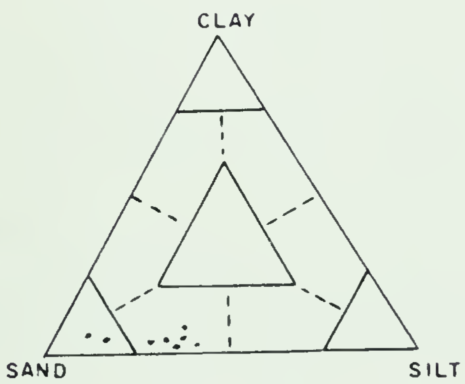
In all of the literature reviewed, the depositional environment of the Nikanassin has been referred to only very briefly. In nearly every instance the author merely states that evidence exists to indicate that both marine and continental conditions were present during sedimentation of the Nikanassin. Results obtained in this work support these beliefs and further indicate that the environment may have been that of a low lying, fresh to brackish estuary or swamp. In this way, the environment may have been similar to many modern bays along the Gulf Coast.

COMPARISON OF SAND - SILT AND CLAY RATIOS
WITH A RECENT GULF COAST ENVIRONMENT



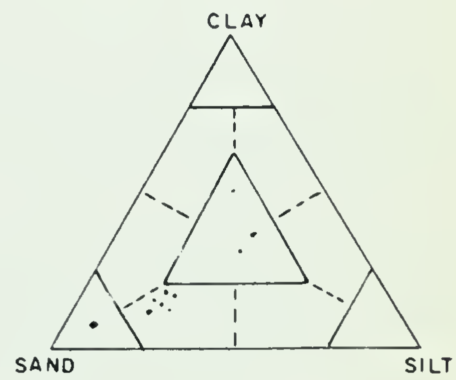
NOMENCLATURE BASED ON SAND - SILT - CLAY PERCENTAGES

(AFTER SHEPARD AND MOORE 1955)



NIKANASSIN FORMATION

TRIANGULAR DIAGRAM SHOWING SAND -SILT-CLAY CONTENTS OF SANDSTONES FROM THE NIKANASSIN FORMATION OF THE TYPE AREA



SHALLOW BAYS
(AFTER SHEPARD AND MOORE 1955)

TRIANGULAR DIAGRAM SHOWING SAND-SILT-CLAY CONTENTS OF SAMPLES FROM A SHALLOW BAY ENVIRONMENT OF THE GULF COAST REGION

FIGURE 17

CONCLUSIONS

The Nikanassin formation of the type area, near Cadomin, Alberta, consists of interbedded very fine grained sandstones and silty shales which are partially continental and partially marine. Very thin stringers of coal and abundant irregular carbonaceous markings occur throughout the formation.

From the palaeontological evidence presented and that given by Warren and Stelck (1958), it appears as though the Nikanassin formation of the type area ranges from late Oxfordian in age to about the end of the Jurassic.

Although this study of the Nikanassin is a local one and resultant regional conclusions must be reached with caution, it nevertheless does appear that the majority of the minerals of the Nikanassin could have been derived from a sedimentary (early Jurassic or older) source. Additional source areas may have been either the Laurentia craton to the east or igneous islands which were appearing in the sea to the west at this time.

Deposition of the Nikanassin formation probably took place in shallow, fresh to brackish water embayments which may have been connected to the open sea by narrows through which marine water intermittently made its way into the site of deposition. The presence of siderite and abundant organic detritus suggests that slightly reducing conditions prevailed during much of the history of the Nikanassin basin.

SELECTED BIBLIOGRAPHY

Anderson, F.M. (1945): Knoxville Series in the California Mesozoic; Geol. Soc. Amer., Vol.56, p.909-1014.

Arkell, W.J. (1933): The Jurassic System of Great Britain; 681 pages, Oxford, England.

Arnold, C.A. (1947): An Introduction to Paleobotany; McGraw-Hill, New York and London, 1947, First Edition.

Bell, W.A. (1956): Lower Cretaceous Floras of Western Canada; Geol. Surv. Can., Mem.285.

Bramlette, M.N. (1941): The stability of minerals in sandstone; Jour. Sed. Pet., Vol.II, p.32-36.

Cushman, J.A. (1955): Foraminifera; Harvard University Press; Cambridge, Mass., 1955, Fourth Edition.

Doeglas, D.J. (1946): Interpretation of Mechanical Analyses; Jour. Sed. Pet., Vol.16, p.19-40.

Dowling, D.B. (1910): Coalfields of Jasper Park, Alberta; Geol. Surv. Can., Sum. Rept., p.150-168.
(1911): Geology of Roches Miette Map Area, Jasper Park, Alberta; Geol. Surv. Can., Sum. Rept., p.201-219.
(1913): North Saskatchewan River Coal Areas, Alberta; Geol. Surv. Can., Sum. Rept.

Emery, K.D. (1954): Some characterisitcs of S. California Sediments; Jour. Sed. Pet., Vol.24, No.1, p.50-59.

Erdman, O.A. (1950): Alexo and Saunders Map Area, Alberta; Geol. Surv. Can., Mem.254.

Freebold, H. (1957): The Jurassic Fernie Group in the Canadian Rocky Mountains and Foothills; Geol. Surv. Can., Mem.287.

Glaister, R.P. (1959): Lower Cretaceous of Southern Alberta and Adjoining Areas; Amer. Assoc. Petrol. Geol. Bull., Vol.43, No.3, Pt.1, p.590.

Henderson, J. (1935): Fossil Non-Marine Mollusca of North America; Geol. Surv. Amer., Spec. Paper No.3.

Irish, E.J. (1951): Pierre Greys Lakes Map Area, Alberta; Geol. Surv. Can., Mem.258.

Kirchner, Z. (1958): A new method of hard rock maceration; Micropaleo., Vol.4, No.3, p.327.

Knowlton, F.H. (1914): The Jurassic Flora of Cape Lisburne, Alaska; U.S. Geol. Surv., Prof. Paper 85-D.

Krumbein, W.C. and Garrels, R.M. (1952): Origin and classification of chemical sediments in terms of pH and oxidation-reduction potentials; Jour. Geol., Vol.60, No.1, p.1-33.

Krumbein, W.C. and Pettijohn, F.J. (1938): Manual of Sedimentary Petrography; 547 pages, Appelton-Century-Crofts, Inc., New York, First Edition.

Krumbein, W.C., Sloss, L.L., and Dapples, E.C. (1949): Sedimentary tectonics and sedimentary environments; Amer. Assoc. Petrol. Geol., Vol.33, p.1859-1871.

Krynine, P.D. (1946): The Tourmaline Group in Sediments; Jour. Geol., Vol.54, p.65-87.

Lang, A.H. (1946): Brule Map Area, Alberta; Geol. Surv. Can., Paper 46-5.

MacKay, B.R. (1929): Mountain Park Sheet; Geol. Surv. Can., Map 208A.
(1929): Cadomin Sheet; Geol. Surv. Can., Map 209A.
(1930): Stratigraphy and Structure of the Bituminous Coal-fields in the vicinity of Jasper Park, Alberta; Trans. C.I.M.M., Vol.33, p.473-504.
(1940): Grave Flats, Alberta; Geol. Surv. Can., Paper 40-15.
(1941): Brazeau, Alberta; Geol. Surv. Can., Paper 41-4.
(1943): Foothills Belt of Central Alberta; Geol. Surv. Can., Paper 43-3.

Malloch, G.S. (1911): Bighorn Coal Basin, Alberta; Geol. Surv. Can., Mem. 9.

McKee, B. and Weir, J. (1953): Terminology for Stratification and Cross-Stratification in Sediments; Geol. Soc. Amer. Bull., Vol.64, p.381-390.

McLearn, F.H. (1944A): Revision of the Lower Cretaceous of the Western Interior of Canada; Geol. Surv. Can., Paper 44-17.

Miller, R.L. (1954): A model for analysis of environments of sedimentation; Jour. Geol., Vol.62, p.108-113.

Olson, J.S. and Potter, P.E. (1954): Variance components in some basal Penn. sandstones of the Eastern Interior Basins; Jour. Geol. Vol.62, p.26-49.

Parker, F.L., Phleger, F.B. and Pierson, J.F. (1953): Ecology of Foraminifera from San Antonio Bay and environs, southeast Texas; Cushman Found. Foram. Research, Spec. Publication, No.2.

Peterson, K.E. (1958): Magnetic Method for Concentrating Foraminifera; Jour. Alberta Soc. Petrol. Geol., Vol.6, No.4, p.111.

Pettijohn, F.J. (1949): Sedimentary Rocks; 526 pages, Harper and Bros., New York, First Edition.
(1957): Sedimentary Rocks; 718 pages, Harper and Bros., New York, Second Edition.

Phleger, F.B. and Walton, W.R. (1950): Ecology of marsh and bay Foraminifera, Barnstable, Mass., Amer. Jour. Sci., Vol.248, p.274-294.

Potter, P.E. (1955): The Petrology and Origin of the Lafayette Gravel (Part 1); Jour. Geol., Vol.63, No.1, p.1-38.

Potter, P.E. and Siever, R. (1956): Sources of Basal Pennsylvanian sediments in the Eastern Intermontane Basin; Jour. Geol., Vol.64, Nos.3 and 4, p.225-244, p.317-335, p.447-455.

Plumley, W.J. (1948): Black Hills Terrace Gravels - A Study in Sediment Transport; Jour. Geol., Vol.56, p.1725-1780.

Rittenhouse, G. (1943): The transportation and deposition of heavy minerals. Geol. Soc. Amer. Bull., No.54, p.1725-1780.

Rogers, A.F. and Kerr, P.F. (1942): Optical Mineralogy; 390 pages, McGraw-Hill, New York and London, Second Edition.

Rutherford, R.L. and Allan, J.A. (1923): Saunders Creek and Nordegg Coal Basin, Alberta; Sci. and Ind. Res. Council of Alta., Rept. No.6.
(1923): Geology of the Foothills Belt between McLeod and Athabasca Rivers, Alta., Sci. and Ind. Res. Council of Alta., Rept. No.11.

Shepard, F.P. and Moore, B.G. (1955): Central Texas Coast Sedimentation, Amer. Assoc. Petrol. Geol. Bull., Vol.39, No.8, p.1463.

Siever, R. (1953): Petrology and Sedimentation - Upper Chester Sandstones; Jour. Sed. Pet., Vol.23, No.4, p.207-219.

Spivak, J. (1949): Jurassic sections in Foothills of Alberta and N.E. B.C.; Amer. Assoc. Petrol. Geol. Bull., Vol.23, No.4, p.533-546.

Stewart, J.S. (1916): Coal Mines of West Central Alberta; Geol. Surv. Can., Sum. Rept.

Twenhofel, W.H. (1945): The rounding of sand grains; Jour. Sed. Pet., Vol.15, p.59-71.

Twenhofel, W.H. and Tyler, S.A. (1941): Methods of study of sediments; McGraw-Hill, New York and London, First Edition.

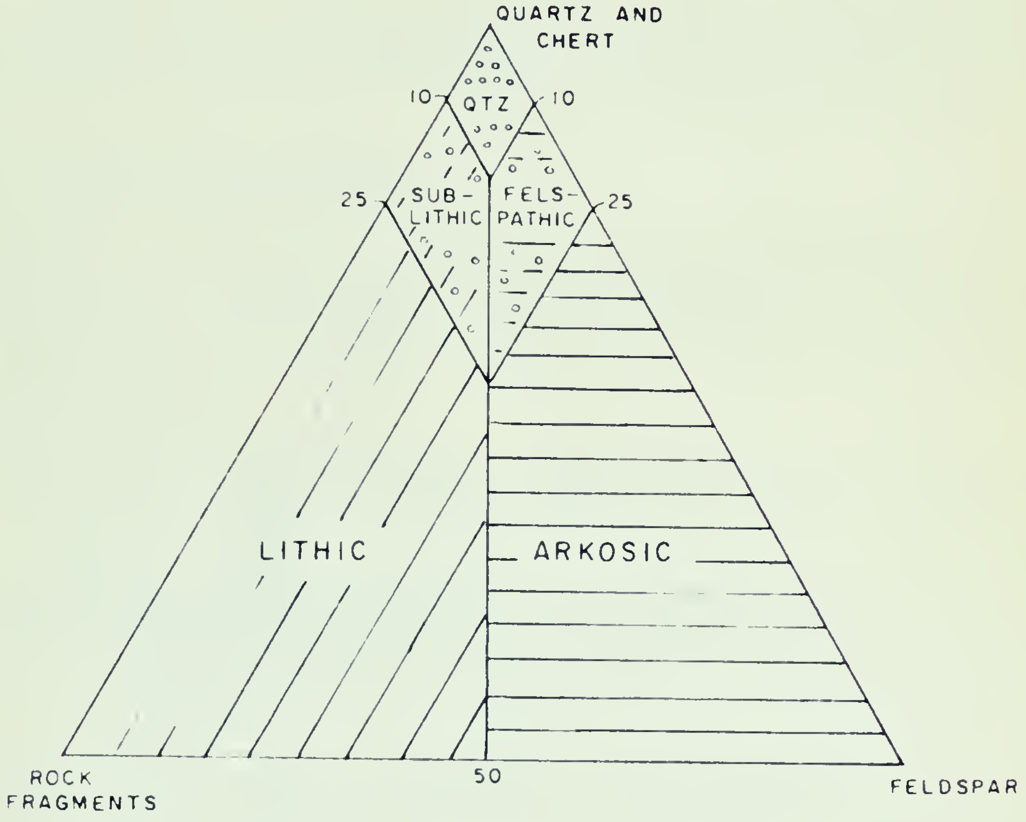
Warren, P.S. and Stelck, C.R. (1958): The Nikanassin-Luscar hiatus in the Canadian Rockies; Trans. Roy. Soc. Canada, 3rd Series, Vol.52, Sec.4.

Weaver, C.E. (1955): Mineralogy and Petrology of the Rocks Near the Quadrant-Phosphoria Boundary in S.W. Montana; Jour. Sed. Pet., Vol.25, No.3, p.163-193.

Williams, H., Turner, F.J. and Gilbert, C.M. (1954): Petrography; 406 pages, W.H. Freeman and Co., San Francisco, 1954.

SANDSTONE CLASSIFICATION AND NOMENCLATURE

(MODIFIED WILLIAMS, TURNER AND GILBERT, 1954)



WACKE —— SANDSTONE IN WHICH MATRIX EXCEEDS 15 %

ARENITE — SANDSTONE IN WHICH MATRIX IS LESS THAN 15 %

ALL PARTICLES FINER THAN 0.1 MM. ARE CLASSED WITH THE MATRIX

FIGURE 18

APPENDIX A

THIN SECTION DESCRIPTIONS

SECTION: Cadomin Railroad-1
LOCATION: Longitude: 117° 19' 55"
Latitude: 53° 00' 45"
TOTAL THICKNESS MEASURED: 961 feet.

SLIDE 3543 - 80' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Light orangish-brown, weathers medium orange brown, very fine grained, thin-bedded, platy, micaceous, argillaceous, slightly calcareous, carbonaceous, porosity poor to nil.

Microscopic Description

TEXTURE: Siltstone bordering on very fine grained sandstone, angular to subangular, well sorted, porosity poor.
STRUCTURE: Discoidal inclusion of shale cuts diagonally across the siltstone.
MINERALOGY:
Principal Constituents: Quartz 65-70%
Matrix: Muscovite and illite, pyrite and carbonaceous material, - total - 3-5%
Cement: None observed
CLASSIFICATION: Highly argillaceous, micaceous siltstone.

SLIDE 3549 - 190' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Medium greyish-brown, weathers light brown and light orangish brown, very fine grained, thin-bedded, slabby to flaggy, laminated, cross-bedded, micaceous, argillaceous, carbonaceous, calcareous, porosity fair.

Microscopic Description

TEXTURE: Very fine to fine-grained sandstone, angular to subrounded, tightly packed, well sorted.
STRUCTURE: One major fracture across the slide, grains fractured are generally filled with authigenic carbonate material. Fine, simple cross-bedding is apparent.
MINERALOGY:
Principal Constituents: Quartz (including silica overgrowths) 45%, twinned feldspar less than 5%, siliceous rock fragments 10-15%, argillaceous rock fragments 15%.

Matrix: Quartz, rock fragments, muscovite and illite, - total - 5-10%.
Cement: Calcite, carbonaceous and ferruginous material, - total - 5-10%.
CLASSIFICATION: Lithic arenite.

SLIDE 3552 - 352' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Dark-grey, weathers light brown and light orangish brown, very fine grained, finely laminated, thin-bedded, platy, calcareous, micaceous, argillaceous, carbonaceous, porosity fair to poor.

Microscopic Description

TEXTURE: Very fine to fine-grained sandstone, angular to subrounded, porosity less than 3%, poorly sorted.
STRUCTURE: Cross-bedding straight and simple, carbonaceous laminae are irregular and discontinuous.
MINERALOGY:
Principal Constituents: Quartz, 40%, twinned feldspar less than 5%, siliceous rock fragments 5-10%, argillaceous rock fragments 5-7%.
Matrix: Quartz, carbonaceous material, pyrite (?), argillaceous and siliceous rock fragments, illite and muscovite, - total - 35%.
Cement: None observed.
CLASSIFICATION: Lithic wacke.

SLIDE 3554 - 408' below the Cadomin conglomerate.

Megascopic Description

(Quartzitic) SANDSTONE: Medium-grey, weathers bright light orange, fine-grained, thin-bedded, fractured perpendicular to the bedding, no laminae, calcareous (?), micaceous, porosity poor.

Microscopic Description

TEXTURE: Fine-grained sandstone, subrounded to subangular, porosity very poor, well sorted. Many of the quartz grains display sutured contacts.
STRUCTURE: None observed.
MINERALOGY:
Principal Constituents: Quartz 70%, siliceous rock fragments 1-5%, twinned feldspar less than 5%, argillaceous rock fragments 5-8%.

Matrix: Quartz, siliceous and argillaceous rock fragments, illite and muscovite, - total - 5-7%.
Cement: Calcite and silica overgrowths on quartz, - total - 10%.
CLASSIFICATION: Sublithic arenite.

SLIDE 3555 - 500' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Medium-grey, weathers light reddish orange and light orangish brown, fine-grained, thin-bedded, slabby and flaggy, micaceous, argillaceous, carbonaceous, very slightly calcareous, porosity fair.

Microscopic Description

TEXTURE: Fine- to medium-grained sandstone, subangular to rounded, loosely packed, sorting is fair to poor. Fractured grains are sealed with authigenic calcite.
STRUCTURE: None observed.
MINERALOGY:
Principal Constituents: Quartz 45-50%, twinned feldspar less than 3%, siliceous rock fragments 5-10%, argillaceous rock fragments 5-10%.
Matrix: Quartz, siliceous and argillaceous rock fragments, carbonaceous material, pyrite, muscovite and illite, - total - 15-20%.
Cement: Partially calcite and partially silica overgrowths on quartz, - total - 10-12%.
CLASSIFICATION: Sublithic wacke.

SLIDE 3556 - 720' below the Cadomin conglomerate.

Megascopic Description

(Quartzitic) SANDSTONE: Medium-brown, and greyish-brown, weathers light brown and dark brownish grey, very fine grained, thin- to medium-bedded, blocky, slightly micromicaceous, slightly argillaceous, porosity poor to nil.

Microscopic Description

TEXTURE: Very fine grained sandstone, subrounded to subangular, tightly packed (porosity 1% or less), well sorted.
STRUCTURE: None observed.
MINERALOGY:
Principal Constituents: Quartz 80%, siliceous rock fragments 5%.
Matrix: Twinned and slightly altered feldspar, quartz, argillaceous and carbonaceous rock fragments, - total - 1-5%.
Cement: Silica overgrowths on quartz, 5-10%.
CLASSIFICATION: Quartz arenite.

SLIDE 3560 - 840' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Dark brownish-grey, weathers light brown and light greyish-brown, very fine grained, thin-bedded, blocky, argillaceous, partially quartzitic, micaceous, very slightly calcareous to noncalcareous, porosity poor.

Microscopic Description

TEXTURE: Fine-grained sandstone, angular to subrounded, closely packed, sorting poor to fair. Some of the fractured quartz grains have been sealed with a secondary silica cement.
STRUCTURE: The slide as a whole shows a good gradation of bedding.
MINERALOGY:
Principal Constituents: Quartz 60-65%, twinned feldspar 3% and less, siliceous rock fragments 10-12%, argillaceous rock fragments 1%.
Matrix: Quartz, siliceous rock fragments, feldspar, carbonaceous material, muscovite, - total - 11%.
Cement: Silica overgrowths on quartz, 8%.
CLASSIFICATION: Quartz arenite.

SLIDE 3562 - 878' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Dark-grey, weathers dark brownish grey, very fine grained, some minor laminae, thin-bedded, flaggy, slightly quartzitic, very slightly calcareous, highly argillaceous, partially carbonaceous (?), micaceous, porosity poor.

Microscopic Description

TEXTURE: Very fine grained sandstone, angular to subrounded, closely packed, well sorted.
STRUCTURE: None observed.
MINERALOGY:
Principal Constituents: Quartz 75%, siliceous rock fragments 5%, argillaceous rock fragments 2-3%, twinned feldspar 2%.
Matrix: Muscovite and illite, carbonaceous material and pyrite, - total - 5-10%.
Cement: Silica overgrowths on quartz and some calcite, - total - 5%.
CLASSIFICATION: Quartz arenite.

SLIDE 3563 - 965' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Medium-greyish-brown, weathers light yellowish and light orangish brown, very fine grained, carbonaceous partings evident, thin-bedded, slabby to flaggy, slightly calcareous, argillaceous, micromicaceous, porosity fair.

Microscopic Description

TEXTURE: Very fine grained sandstone, subangular to subrounded, tightly packed, well sorted.
STRUCTURE: None observed.
MINERALOGY:
Principal Constituents: Quartz 80-85%, siliceous rock fragments 3%, argillaceous rock fragments 1% and less.
Matrix: Quartz, siliceous rock fragments, twinned feldspar, carbonaceous material, muscovite and illite, - total - 5-9%.
Cement: Calcite and silica overgrowths on quartz - total - 3-5%.
CLASSIFICATION: Quartz arenite.

SECTION: Mountain Park Railroad-1
LOCATION: Longitude: 117° 18' 10"
Latitude: 52° 57' 00"
TOTAL THICKNESS MEASURED: 420 feet.

SLIDE 3568 - 75' below the glauconite marker bed.

Megascopic Description

SANDSTONE: Medium-light- and medium-dark-grey, weathers dark yellowish brown, very fine to fine-grained, strongly laminated, highly micaceous, slightly calcareous, carbonaceous, porosity fair to poor.

Microscopic Description

TEXTURE: Fine-grained sandstone, angular to subangular, loosely packed, normal to well sorted.
STRUCTURE: Simple straight cross-beds are displayed and accentuated by dark irregular carbonaceous laminae.
MINERALOGY:
Principal Constituents: Quartz 50-55%, twinned feldspar 5%, siliceous rock fragments 5%, argillaceous rock fragments 5%.
Matrix: Carbonaceous material (including coal), pyrite, quartz and siliceous rock fragments, muscovite and illite, - total - 10-15%.
Cement: Calcite, 10-15%.

SLIDE 3572 - 140' below the glauconite marker bed.

Megascopic Description

SANDSTONE: Pale-brownish-grey, weathers moderate yellowish brown, very fine grained, laminated, finely cross-bedded, noncalcareous, argillaceous, carbonaceous, slightly quartzitic, micaceous, porosity poor to nil.

Microscopic Description

TEXTURE: Fine-grained sandstone, subangular to subrounded, closely packed, well sorted. Flakes of mica have been contorted by post-depositional compression of the adjacent quartz grains.
STRUCTURE: None observed.
MINERALOGY:
Principal Constituents: Quartz and siliceous rock fragments 70-75%, twinned feldspar 5%.
Matrix: Quartz, carbonaceous material, pyrite, arenaceous shale fragments, muscovite and illite, - total - 5-10%.
Cement: Silica overgrowths on quartz, 5-10%.
CLASSIFICATION: Sublithic arenite.

SLIDE 3576 - 200' below the glauconite marker bed.

Megascopic Description

SANDSTONE: Medium-grey, weathers pale yellowish brown to light olive grey, very fine grained to fine-grained, thin- to medium-bedded, flaggy, laminated, cross-bedded, partially quartzitic, noncalcareous, micromicaceous, argillaceous, porosity poor to nil.

Microscopic Description

TEXTURE: Fine-grained sandstone, angular to subrounded, closely packed, well to normally sorted.
STRUCTURE: Some of the siliceous rock fragments are extremely well rounded.
MINERALOGY:
Principal Constituents: Quartz 60-70%, twinned feldspar less than 5%, siliceous rock fragments 5%, argillaceous rock fragments 2-5%.
Matrix: Quartz, muscovite, carbonaceous material, illitic clay material, pyrite, - total - 10%.
Cement: Silica overgrowths on quartz, 3%.
CLASSIFICATION: Sublithic arenite.

SLIDE 3578 - 240' below the glauconite marker bed.

Megascopic Description

(Quartzitic) SANDSTONE: Medium-grey to medium-olive-grey, weathers dusky yellow, very fine grained, laminated, cross-bedded, thick-bedded, micaceous, slightly calcareous, partially argillaceous, porosity fair.

Microscopic Description

TEXTURE: Fine-grained sandstone, angular to subangular, closely packed, well to normally sorted.
STRUCTURE: None observed.
MINERALOGY:
Principal Constituents: Quartz 70%, twinned feldspar 5%, siliceous rock fragments 5-10%.
Matrix: Quartz, argillaceous rock fragments, carbonaceous matter, pyrite, illite and muscovite, - total - 5%.
Cement: Silica overgrowths on quartz and some calcite, - total - 5-10%.
CLASSIFICATION: Quartz arenite.

SLIDE 3581 - 285' below the glauconite marker bed.

Megascopic Description

SANDSTONE: Medium-brownish-grey, weathers dark reddish brown, very fine grained, finely laminated, thin-bedded, platy to flaggy, highly argillaceous, carbonaceous, slightly calcareous, micaceous, porosity fair.

Microscopic Description

TEXTURE: Fine-grained sandstone, angular to subangular, loosely packed, poorly sorted.
STRUCTURE: Laminated and cross-bedded. Also, some suggestion of graded bedding evident.
MINERALOGY:
Principal Constituents: Quartz and siliceous rock fragments 40%, twinned feldspar 2%, argillaceous rock fragments 20%.
Matrix: Quartz, feldspar, muscovite, carbonaceous material, illite, pyrite, - total - 21%.
Cement: Finely disseminated ferruginous material, - total - 10-15%.
CLASSIFICATION: Lithic wacke.

SECTION: Mackenzie Creek-1
LOCATION: Longitude: 117° 10' 30"
Latitude: 52° 56' 45"
TOTAL THICKNESS MEASURED: 1265 feet.

SLIDE 3586 - 190' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Dark-blackish-grey, weathers pale yellowish brown and light greyish brown, fine-grained, medium- to thick-bedded, slabby, some lamination, highly calcareous, carbonaceous, argillaceous, micaceous, porosity poor.

Microscopic Description

TEXTURE: Fine- to medium-grained sandstone, angular to subrounded, loosely packed, poor to normal sorting.
STRUCTURE: Cross-bedded and irregularly laminated.
MINERALOGY:
Principal Constituents: Quartz and siliceous rock fragments 25%, argillaceous and carbonate rock fragments 20-25%, twinned feldspar 1%.
Matrix: Carbonaceous material, quartz, siliceous and argillaceous rock fragments, pyrite, - total - 10-15%.
Cement: Calcite 30-35%.
CLASSIFICATION: Lithic wacke.

SLIDE 3598 - 950' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Light-grey, weathers light olive to pale yellowish brown, fine- to medium-grained, medium- to thin-bedded, slabby to blocky, laminated, slightly micaceous, noncalcareous, except for dark laminae, is noncarbonaceous and nonargillaceous, porosity fair.

Microscopic Description

TEXTURE: Fine- to medium-grained sandstone, subrounded, closely packed, well sorted.
STRUCTURE: None observed.
MINERALOGY:
Principal Constituents: Quartz and siliceous rock fragments 85%.
Matrix: Twinned feldspar, argillaceous rock fragments and carbonaceous material, - total - 5%.
Cement: Silica overgrowths on quartz 8-10%.
CLASSIFICATION: Quartz arenite.

SLIDE 3607 - 1234' below the Cadomin conglomerate.

Megascopic Description

SANDSTONE: Medium-dark-grey, weathers brownish grey, very fine to fine-grained, thick- to medium-bedded, blocky to slabby, highly laminated, carbonaceous, argillaceous, minor micromica, noncalcareous, porosity poor.

Microscopic Description

TEXTURE: Fine-grained sandstone, subangular, tightly packed, well sorted. Numerous sutured grain boundaries were observed.
STRUCTURE: None observed.
MINERALOGY:
Principal Constituents: Quartz and siliceous rock fragments 75%, twinned feldspar 1%.
Matrix: Argillaceous rock fragments, carbonaceous material, pyrite, - total - 15%.
Cement: Silica overgrowths on quartz, calcite, and some finely disseminated ferruginous material, - total - 10%.
CLASSIFICATION: Quartz arenite bordering on sublithic arenite.

APPENDIX B

LOCATION OF HEAVY MINERAL SAMPLES

Section	Interval Sampled	Sample Footage
Prospect Creek-1	0' - 100'	50'
Cadomin Railroad-1	0' - 100'	56'
	0' - 100'	64'
	100' - 200'	160'
	200' - 300'	210'
	300' - 400'	356'
	400' - 500'	410'
Mackenzie Creek-1	500' - 600'	560'
	600' - 700'	640'
	700' - 800'	780'
	800' - 900'	810'
	900' - 1000'	950'
	1000' - 1100'	1070'
	1100' - 1200'	1110'
	1200' - 1300'	1265'

APPENDIX C

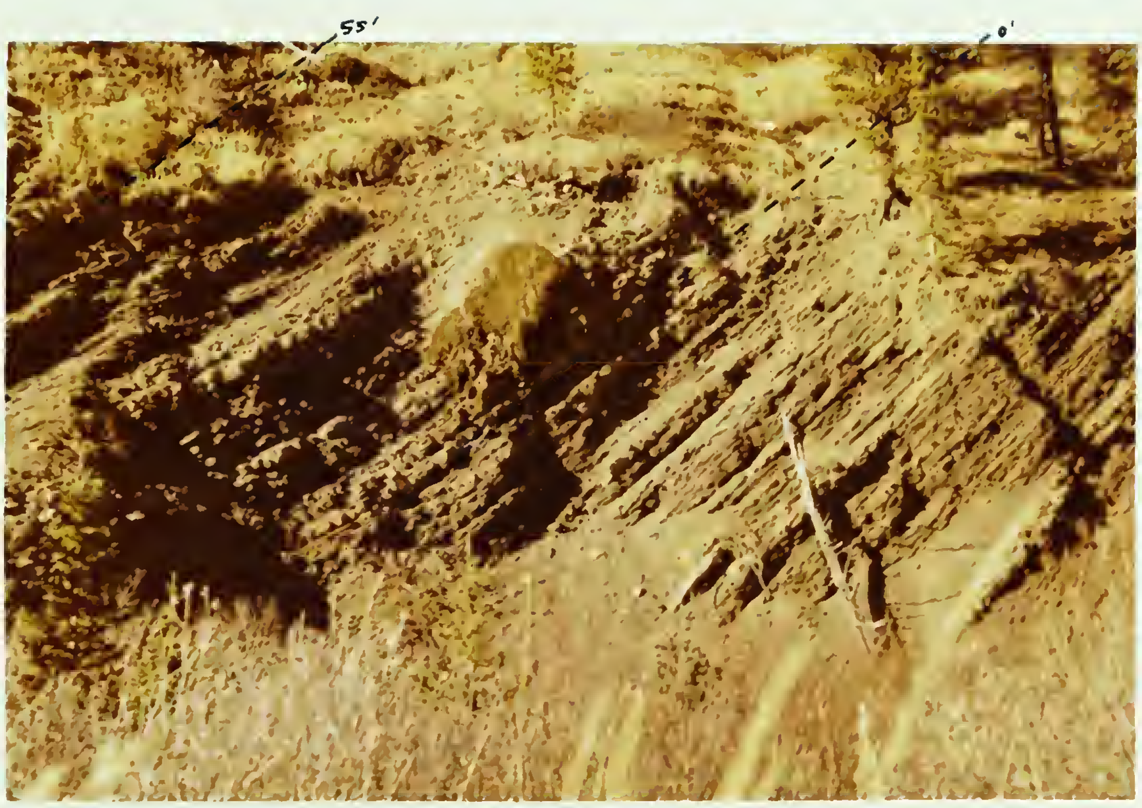
LOCATION OF MEGA- AND MICROFOSSIL SAMPLES

Megafossils

Anadonta (?) sp.------------------------Villeneuve Creek, 300' below the Cadomin conglomerate.
Ginkgo cf. *G. nana* Dawson---------------Villeneuve Creek, 70' below the Cadomin conglomerate.
Pityophyllum cf. *P. nordenskioldi* Heer--Villeneuve Creek, 70' below the Cadomin conglomerate.
Podozamites cf. *P. lanceolatus* (Lindley and Hutton) C.F.W. Braun---Villeneuve Creek, 70' below the Cadomin conglomerate.
Aucella cf. *A. mosquensis* Von Buch-----Drystone Creek, Alberta.
-----Morris Creek, Alberta.

Microfossils

The foraminiferal assemblage listed in Chapter 4 was extracted from samples of the shale interbeds of section P.P.C.-1.



Prospect Creek-1. -- The shale interbeds of the 0 - 55' interval indicated (see photo. above) were sampled for microfaunal study.

APPENDIX D

LOCATION OF THIN SECTION SAMPLES

Section	Slide No.	Sample Footage
Cadomin Railroad-1	3538	0'
	3539	1'
	3540	6'
	3541	35'
	3542	56'
	3543	80'
	3544	90'
	3545	100'
	3546	125'
	3547	135'
	3548	150'
	3549	190'
	3550	240'
	3551	320'
	3552	352'
	3553	356'
	3554	408'
	3555	490'
	3556	720'
	3557	750'
	3558	780'
	3559	800'
	3560	840'
	3561	845'
	3562	878'
	A.K.-1	920'
	A.K.-2	920'
	A.K.-3	920'
	3563	960'
Mountain Park Railroad-1	3564	2'
	3565	34'
	3566	48'
	3567	70'
	3568	75'
	3569	92'
	3570	113'
	3571	125'
	3572	140'
	3573	147'
	3574	167'
	3575	175'
	3576	200'
	3577	223'
	3578	240'
	3579	260'

Section	Slide No.	Sample Footage
	A.K.-4	265'
	A.K.-5	265'
	A.K.-6	265'
	3580	267'
	3581	285'
Mackenzie Creek-1	3582	0'
	3583	100'
	3584	120'
	3585	150'
	3586	190'
	3587	250'
	3588	340'
	3589	460'
	3590	510'
	3591	590'
	3592	620'
	3593	660'
	3594	770'
	3595	810'
	3596	880'
	3597	920'
	3598	950'
	3599	957'
	3600	1000'
	3601	1060'
	3602	1080'
	3603	1130'
	3604	1165'
	3605	1181'
	3606	1223'
	3607	1234'
	3608	1260'
	3609	1265'
Prospect Creek-1	3610	2'
	3611	20'
	3612	40'
	3613	55'

EXPLANATION OF PLATE 10

Photomicrographs of Heavy Minerals

Figure 1: Epidote, irregular shape, "hackly" appearance, bears partial ferruginous coating; x180; Cadomin Railway-1; 210'.

Figure 2: Apatite, stubby prismatic grain, rounded, inclusions present; x180; Mackenzie Creek-1; 810'.

Figure 3: Epidote, slightly irregular shape, subangular to subrounded, partially coated with ferruginous material; x180; Cadomin Railroad-1; 210'.

Figure 4: Zircon, elongate, subhedral, rounded, colorless, inclusions present; x180; Mackenzie Creek-1; 780'.

Figure 5: Zircon, rounded, slightly zoned, colorless to light-brown; x180; Mackenzie Creek-1; 1100'.

Figure 6: Zircon, elongate, subhedral, rounded, colorless, inclusions present; x180; Mackenzie Creek-1; 780'.

Figure 7: Epidote, slightly irregular shape, subangular, "hackly" appearance, minute inclusions; x180; Mackenzie Creek-1; 640'.

Figure 8: Hornblende, prismatic, frayed ends, pleochroic (light to dark green), partially altered; x180; Cadomin Railroad-1; 356'.

Figure 9: Tourmaline, elongate, subrounded, pleochroic (olive brown to olive green); x180; Mackenzie Creek-1; 780'.

PLATE 10

EXPLANATION OF PLATE 11

Photomicrographs of Heavy Minerals

Figure 1: Zircon, elongate, euhedral, pyramidal terminations, zoned, colorless; x180; Mackenzie Creek-1; 1070'.

Figure 2: Zircon, elongate, rounded, colorless to light-greyish-brown; x180; Cadomin Railroad; 210'*

Figure 3: Zircon, elongate, prismatic, colorless, subangular, inclusions present; x180; Mackenzie Creek-1; 780'.

Figure 4: Zircon, elongate, subhedral, colorless, inclusions present; x180; Mackenzie Creek-1; 780'.

Figure 5: Apatite, stubby, irregularly prismatic grain, subangular, inclusions present; x180; Mackenzie Creek-1; 810'.

Figure 6: Tourmaline, rounded, pleochroic (light green to light olive brown), surface slightly pitted; x180; Mackenzie Creek-1; 780'.

Figure 7: Tourmaline, well rounded, pleochroic (light olive green to light greenish yellow), minute inclusions; x180; Mackenzie Creek-1; 780'.

Figure 8: Zircon, elongate, euhedral, light-greyish-brown to colorless, inclusions present; x180; Cadomin Railroad-1; 356'.

Figure 9: Apatite, prismatic, rounded, surface slightly striated and pitted, fine inclusions; x180; Mackenzie Creek-1; 810'.

Figure 10: Zircon, well rounded, colorless to light-grey, surface pitted, inclusions present; x180; Mackenzie Creek-1; 780'.

Figure 11: Zircon, stubby, subhedral, colorless, slightly zoned, inclusions present; x180; Cadomin Railroad-1; 356'.

PLATE II

EXPLANATION OF PLATE 12

Photomicrographs of Heavy Minerals

Figure 1: Cummingtonite, prismatic, pleochroic (light green to light yellowish green), numerous inclusions, surface slightly altered; x180; Prospect Creek-1; 50'.

Figure 2: Diopside, prismatic, subangular to subrounded, inclusions present; x180; Mackenzie Creek-1; 780'.

Figure 3: Hornblende, prismatic, ends frayed, pleochroic (light to dark green), surface altered; x180; Cadomin Railroad-1; 356'.

Figure 4: Rutile, tetrahedral grain, subangular to angular, reddish brown, inclined striae barely visible; x180; Mackenzie Creek-1; 780'.

Figure 5: Rutile, elongate, subangular, reddish-brown; x180; Mackenzie Creek-1; 810'*

Figure 6: Epidote, irregular angular grain, "hackly" appearance, light-greenish-yellow; x180; Mackenzie Creek-1; 560'.

Figure 7: Garnet, irregular in shape, conchoidal fracture, colorless; x180; Cadomin Railroad-1; 410'.

Figure 8: Zircon, stubby grain, well rounded, colorless, some minute inclusions; x180; Cadomin Railroad-1; 356'.

Figure 9: Apatite, prismatic, subangular, minute inclusions evident; x180; Mackenzie Creek-1; 810'.

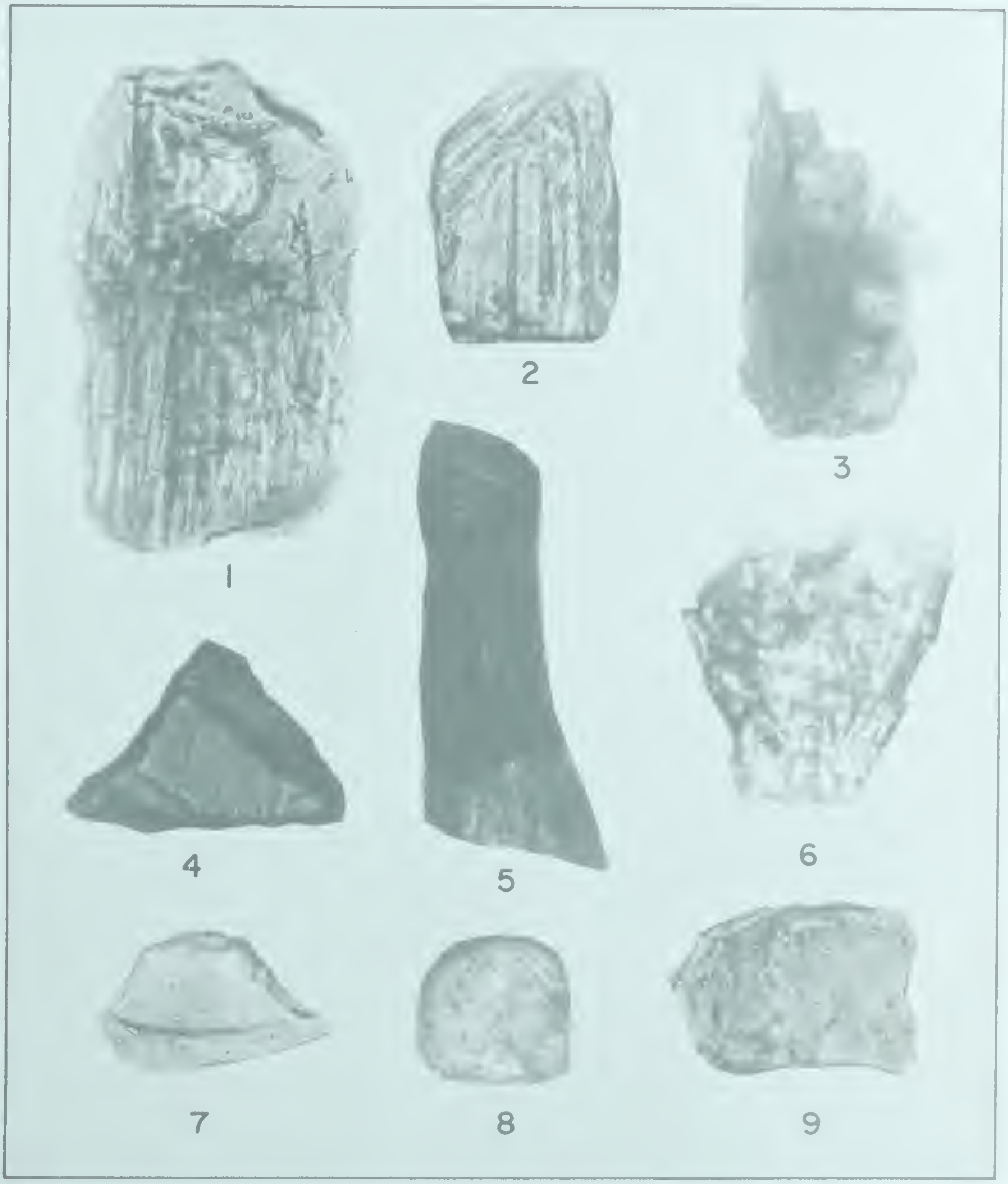


PLATE 12

EXPLANATION OF PLATE 13

Photographs of Megafossils

Figure 1: Aucella cf. A. mosquensis (Von Buch). Hypotype, Geol. Dept., U. of A. x1.4. Nikanassin formation, Loc. on Drystone Creek, Alberta. (Page 63)

Figure 2: Anadonta (?) sp. Hypotype, Geol. Dept., U. of A. x1.4. Nikanassin formation, Loc. on Villeneuve Creek, Alberta. (Page 64)

Figure 3: Aucella cf. A. mosquensis (Von Buch). Hypotype, Geol. Dept. U. of A., Nikanassin formation, Loc. on Morris Creek, Alberta. (Page 63)

Figure 4: Podozamites cf. P. lanceolatus (Lindley and Hutton) C.F.W. Braun. Hypotype, Geol. Dept., U. of A.: and Ginkgo cf. G. nana Dawson; Hypotype, Geol. Dept., U. of A., Nikanassin formation, Loc. on Villeneuve Creek, Alberta. (Pages 61, 62)

Figure 5: Pityophyllum cf. P. nordenskioldi (Heer). Hypotype, Geol. Dept., U. of A. x0.6. Nikanassin formation, Loc. on Villeneuve Creek, Alberta. (Page 60)

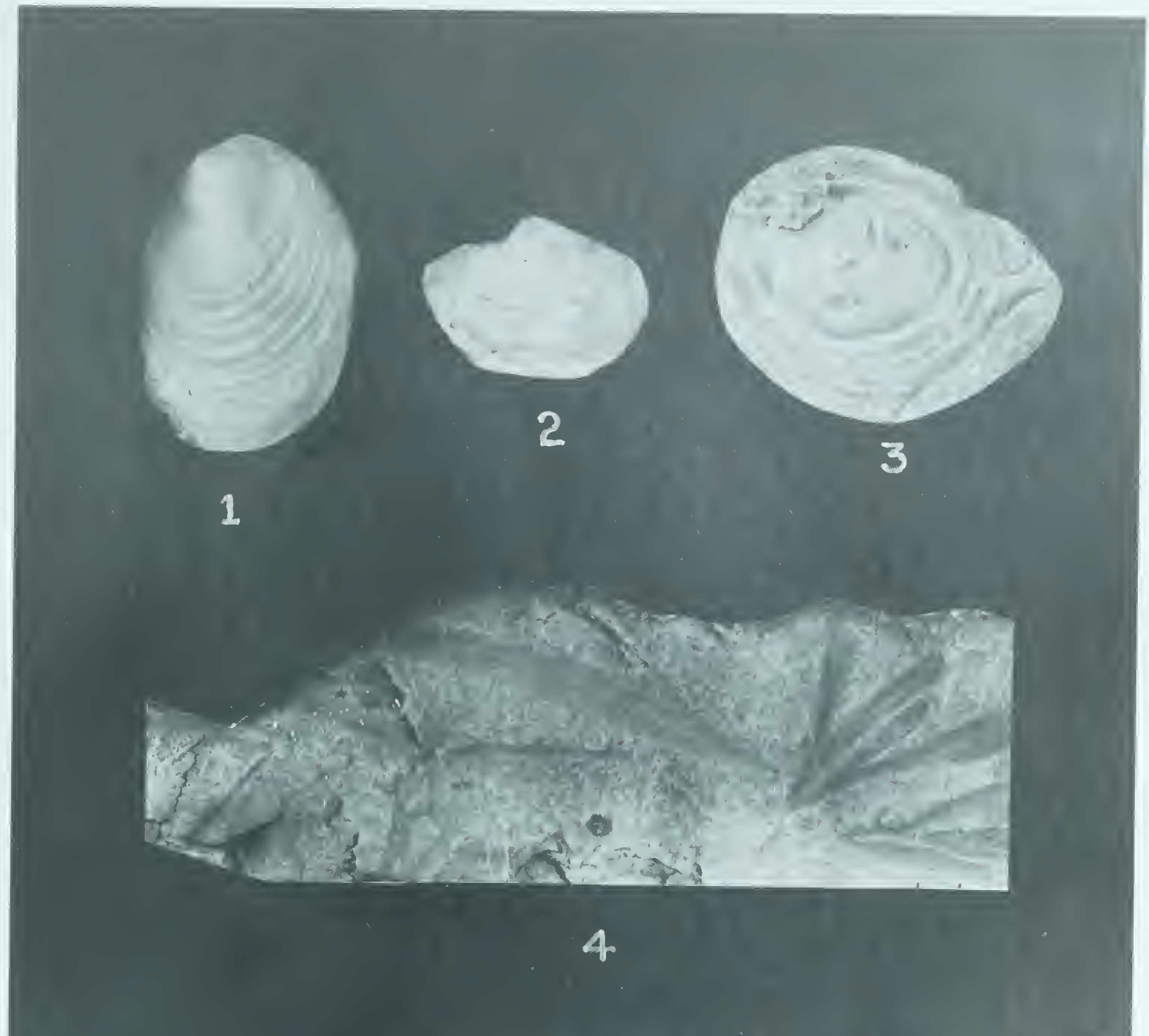


PLATE 13

EXPLANATION OF PLATE 14

Photomicrographs of Thin Sections

Figure 1: Slide 3560; Black carbonaceous material outlines light grey, poorly sorted grains of quartz and feldspar; nicols uncrossed; x100; Cadomin Railroad-1; 840'; described on page 111 .

Figure 2: Slide 3560; Quartz grains large, -black, -white, and grey; feldsp twinned, -grey and white, carbonaceous material black as in Fig. 1; nicols crossed; x100; Cadomin Railroad-1; 840'; described on page 111 .

Figure 3: Slide 3543; Quartz-white; muscovite and illite-white and light-grey, pyrite and carbonaceous material-black. Note the break between highly argillaceous siltstone (in lower half of photo) and normal siltstone (in upper half of photo). Nicols crossed x100; Cadomin Railroad-1; 80'; described on page 108.

Figure 4: Slide 3560; See Figs. 1 and 2; x100; grains are poorly sorted and show gradation of bedding (left to right).

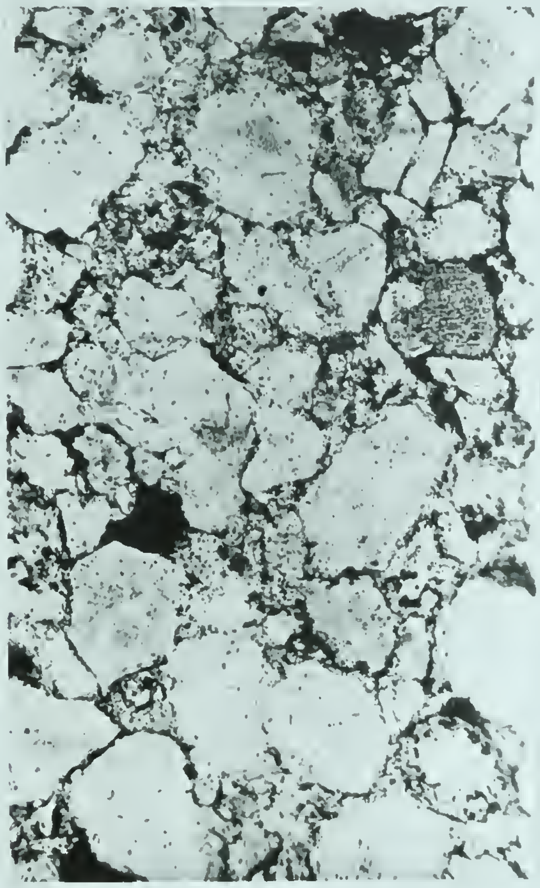
FIGURE 1

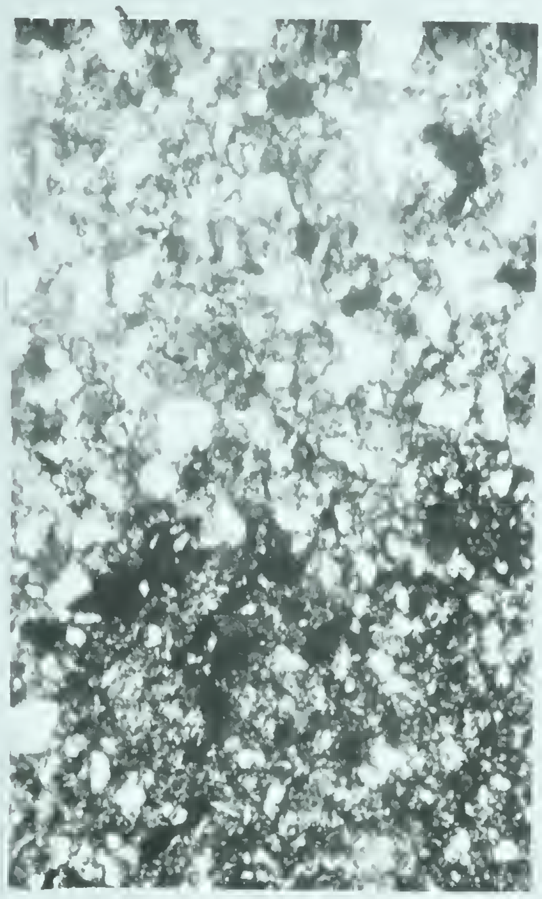
FIGURE 3

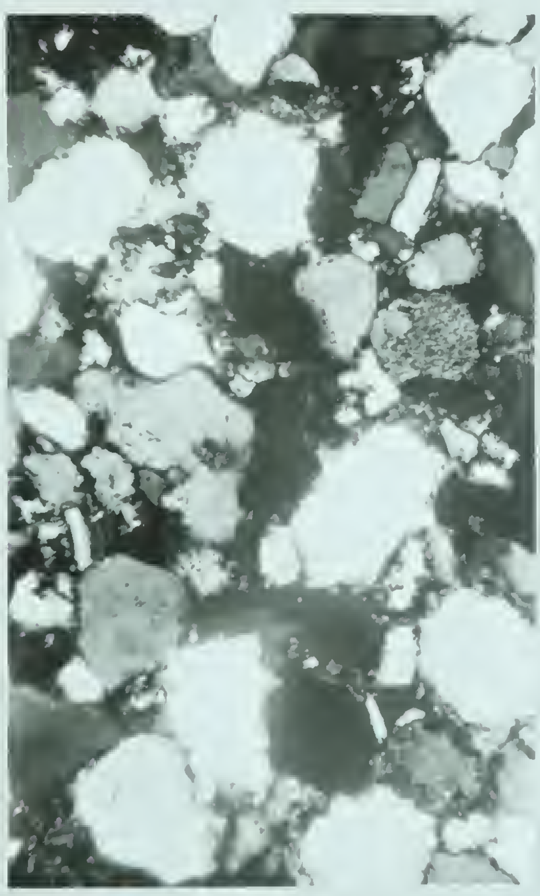
FIGURE 2

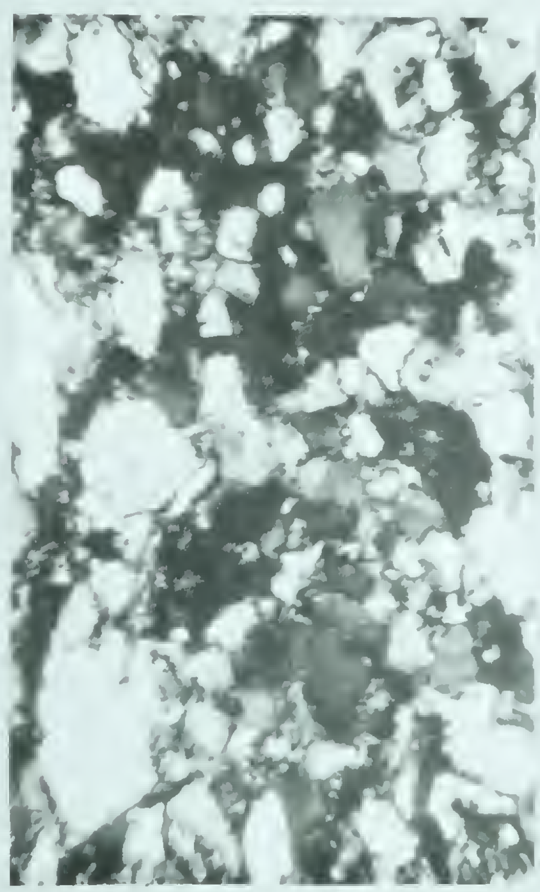
FIGURE 4

PLATE 14









EXPLANATION OF PLATE 15

Photomicrographs of Thin Sections

Figure 1: Slide 3552; Very fine grained lithic wacke, quartz-white and unspotted, rock fragments-light grey and covered with very fine dark grey and black specks, black material is carbonaceous matter and some pyrite (?); nicols uncrossed; x100; Cadomin Railroad-1; 352'; described on page 109.

Figure 2: Slide 3552; Quartz-white and grey, rock fragments finely speckled dark grey and white, carbonaceous material and pyrite-black; crossed nicols; x100; Cadomin Railroad-1; 352'; described on page 109.

Figure 3: Slide 3581; Fine-grained lithic wacke, quartz and siliceous rock fragments-white and light grey, carbonaceous and ferruginous materials-black; nicols uncrossed; x100; Mountain Park Railroad-1; 285'; described on page 114.

Figure 4: Slide 3581; Quartz-grey and white, ferruginous material-dark grey and black, muscovite and illite-irregular masses, finely speckled white and grey; crossed nicols; x100; Mountain Park Railroad-1; 285'; described on page 114.

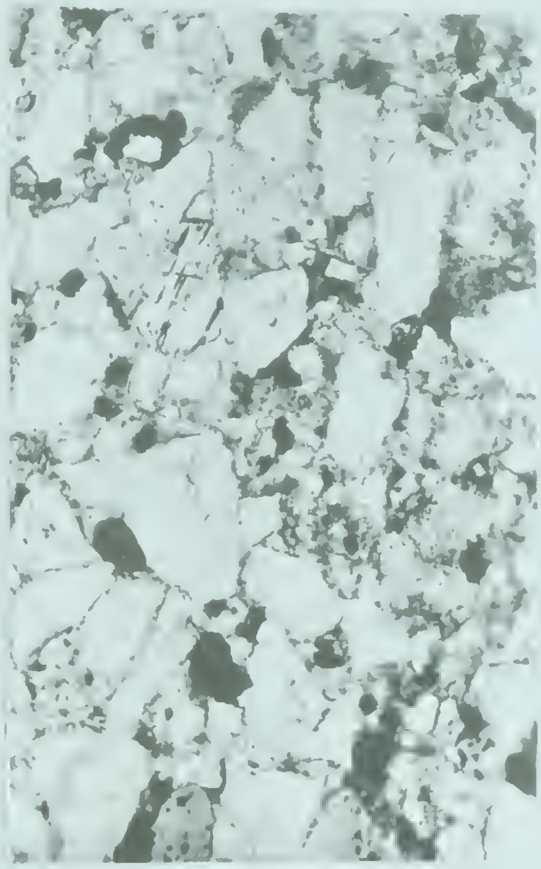
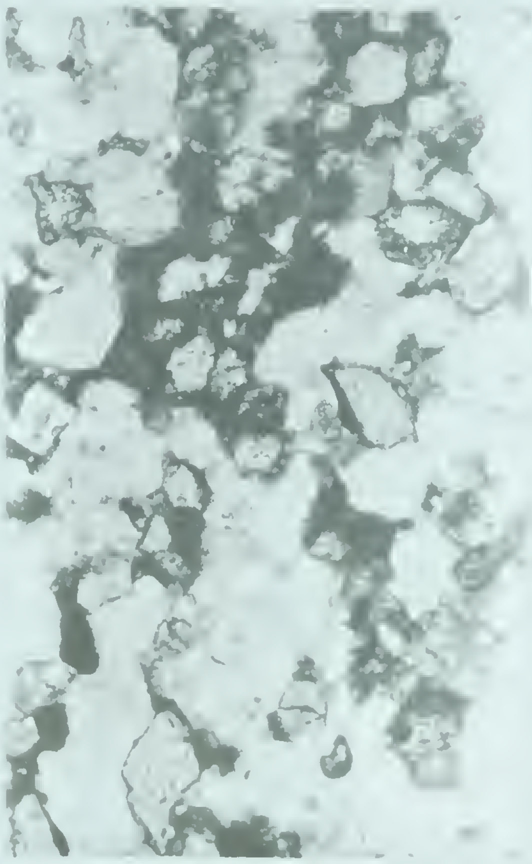
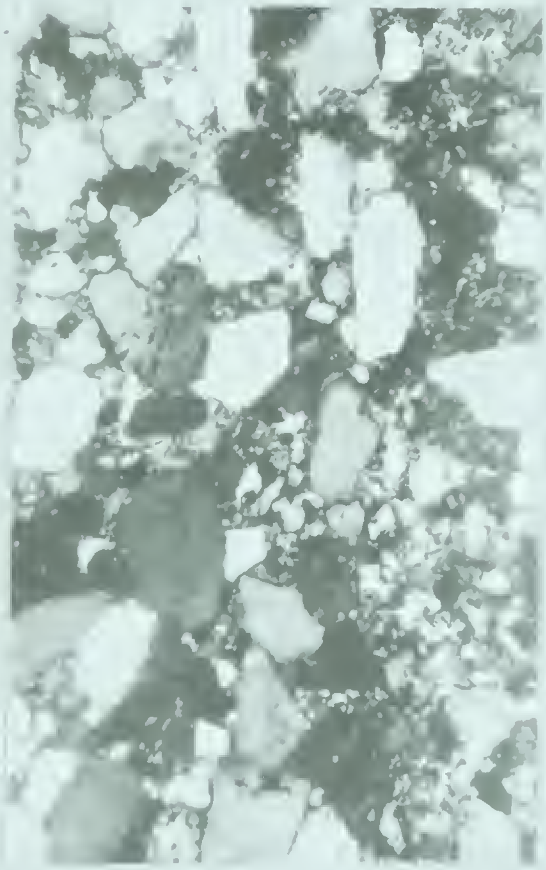
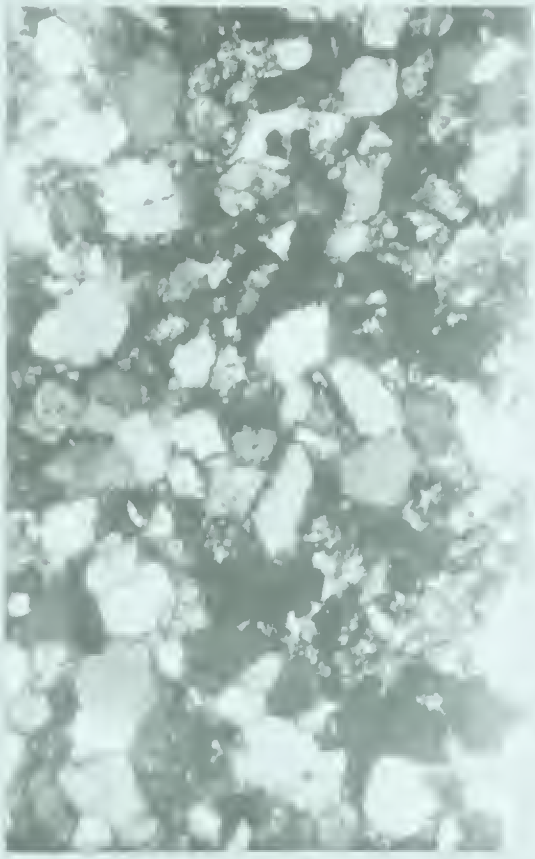
FIGURE 1

FIGURE 3

FIGURE 2

FIGURE 4

PLATE 15

EXPLANATION OF PLATE 16

Photomicrographs of Thin Sections

Figure 1: Slide 3555; Fine- to medium-grained sublithic wacke, quartz-white and grey, argillaceous rock fragments-darkgrey to black; Note: the sutured contacts of the quartz grains, also rounded grain (upper center); crossed nicols; x100; Cadomin Railroad-1; 500'; described on page 110.

Figure 2: Slide 3555; Fine- to medium-grained sublithic wacke, argillaceous rock fragment-black spotted particle (upper center), calcite cement-four whitish-grey grains in center of photo; crossed nicols; x100; Cadomin Railroad-1; 500'; described on page 110 .

Figure 3: Slide 3554; Fine-grained sublithic arenite, argillaceous rock fragments-grey, quartz-white; nicols uncrossed; x100; Cadomin Railroad-1; 408'; described on page 109 .

Figure 4: Slide 3556; Very fine grained quartz arenite, quartz-white, grey & black, note the grain of twinned sodic plagioclase (lower center); crossed nicols; x100; Cadomin Railroad-1; 720'; described on page 110.

FIGURE 1

FIGURE 3

FIGURE 2

FIGURE 4

PLATE 16